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Analyze vehicular flow at the intersection, Fernando Baeza avenues and Chuvíscar River, applying work sampling

Analizar afluencia vehicular del cruce, avenidas Fernando Baeza y Río Chuvíscar, aplicando muestreo del trabajo

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Abstract

It is an innovative work to carry out this analysis of vehicular flow that will be very useful for the city of Delicias Chihuahua, this town is relatively young and lacks road engineering (traffic lights) in some specific points, given the demographic growth of the neighborhoods on the outskirts, this avenue has been a key point to vent the vehicular flow to the different neighborhoods. The continuous improvement technique was applied, which is work sampling, according to ILO establishes that Work sampling is a technique to determine, through statistical analysis and random observations, the percentage of appearance of a certain activity. It will be necessary to continuously observe each of the points in the area and record the moment, at a previously selected time in the same period of time, but at different random times provided by the work sampling. For this investigation, the general objective is: identify the vehicular flow at the intersection of Fernando Baeza and Río Chuvíscar avenues in Ciudad Delicias, Chihuahua. The contribution of this study will benefit more than 79,907 vehicles that are registered in the vehicle registry of the Revenue Collection Office (2022) in the town and in this way apply continuous improvement for the benefit of citizens, identifying the hours of more vehicle capacity and consequently take advantage of cutting-edge technology, and build a road engineering focused on traffic lights for the benefit of its entire population.

Vehicular flow, Traffic lights, Work sampling, Continuous improvement

Resumen

Es un trabajo innovador, el realizar este análisis de flujo vehicular que será de gran utilidad para la ciudad de Delicias Chihuahua, esta localidad es relativamente joven y carece de una ingeniería de vialidad (semaforización) en algunos puntos específicos, dado el crecimiento demográfico de las colonias de la periferia, esta avenida ha sido un punto clave para desfogar su flujo vehicular a las diferentes colonias. Se aplicó la técnica de mejora continua la cual es el muestreo de trabajo, de acuerdo con OIT establece que El muestreo del trabajo es una técnica para determinar, mediante análisis estadístico y observaciones aleatorias, el porcentaje de aparición de determinada actividad. Será necesario observar continuamente cada uno de los puntos de la zona y registrar el momento, en un horario previamente seleccionado en un mismo lapso de tiempo, pero en diferentes horarios aleatorios que arroje el muestreo del trabajo, para esta investigación, el objetivo general es: identificar la afluencia vehicular en la intersección de las avenidas Fernando Baeza y Río Chuvíscar en Ciudad Delicias, Chihuahua. La contribución de este estudio dará como beneficiarios a más de 79,907 automotores que tiene registrados el padrón vehicular de la Oficina de Recaudación de Rentas (2022) en la localidad y de esta manera aplicar una mejora continua en beneficio de la ciudadanía, identificando las horas de más aforo vehicular y por consecuencia aprovechar la tecnología de punta, y construir una Ingeniería de vialidad enfocada hacia la semaforización en beneficio de toda su población.

Flujo vehicular, Semaforización, Muestreo del trabajo, Mejora continua

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Introduction

Work sampling is defined as a technique for determining by statistical sampling and random observations the rate of occurrence of a given activity. Work sampling is based on making observations on some activity at random intervals; if the sample size is adequate, and the observations are truly random, there is a high probability that, with a certain margin of error, the observations reflect the true situation of the observed event. The observed activity has to occur repeatedly in order for sampling to be carried out correctly.

Work sampling W Niebel Benjamin (1988) has advantages such as: it does not require continuous observations by an analyst, a single analyst can easily study what is required, the worker is not subjected to long periods of timed observations, the number of analyst-hours is less. In addition, this method is applicable in companies for the improvement of activities, evaluation of productive and unproductive periods, establishing production standards, work allocation, among other things. However, sampling also has several disadvantages, among them: For Hugo García Mancillas it is not economical for a single operation, as well as it is not economical for repetitive operation times with very short cycles, it does not provide a detailed record of the method used, among other disadvantages.

Description of the method

A nomogram, abacus or nomograph is a graphical calculating instrument, a two-dimensional diagram that allows the graphical and approximate computation of a function of any number of variables. It is an analogue calculation instrument, like the slide rule, because it uses continuous line segments to represent the discrete numerical values that the variables can assume. To develop this work, a straight line is drawn starting from the ordinate p (5-95) cutting the required ordinate error or precision (10%) and extending to the ordinate "number of observations", which cuts off at 10 for a confidence level of 90%. Table 1 below illustrates the above.

As mentioned by Manuel Mancilla in his book, random numbers are those that can be generated from sources of randomness which are generally physical in nature (dice, roulette wheels, electronic or mechanical mechanisms), and are governed by the laws of chance; they exhibit true randomness in the conduct of experiments. The sample size can be determined by applying the nomographic method most easily by directly reading the number of observations required in a nomogram as stated by W Niebel Benjamin (1988) as presented in figure 1. To determine the sample size, the nomographic method was used, with which the percentage of occurrence, the required precision and the number of observations were determined. Since the analysis was carried out to determine car traffic at the traffic light located at the Fernando Baeza Avenue - Rio Chuvíscar Avenue intersection, the data sampled were: number of cars travelling from North to South, South to North, Northeast to Southwest and Southwest to Northeast. When analysing the variables, the data will be recorded and summary tables will be made where the results obtained in the observations will be concentrated; also, in order to better understand, a graphic analysis of the data obtained (per day) will be formulated, and then a tabular and graphic concentration of all the sampled data will be made. The sampling, tables and graphs will help to predict the traffic flow, taking into account the data obtained from the observations, which will allow informed decisions to be made.

The sample size can be determined by applying the nomographic method most easily by directly reading the number of observations required in a nomogram according to W Niebel Benjamin (1988), as presented in table 1. The nomographic method was used to determine the sample size, with which the percentage of occurrence, the required precision and the number of observations were determined. Since the analysis was carried out to determine car traffic at the traffic light located at the Fernando Baeza-Av. Fernando Baeza-Av. Río Chuvíscar intersection, the data sampled were: number of cars travelling from north to south, south to north, northeast to southwest and southwest to northeast.

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Opportunity identified

A study of the nature of the present one had not been carried out previously in the City of Delicias, at the Avenida Fernando Baeza - Avenida Río Chuvíscar intersection, so this research is relevant given the current situation, as mentioned by Mądziel, M. and Campisi, T. (2023). A study by Skuza and Jurecki indicates that one of the most sought-after aspects of an electric vehicle is its energy consumption. This parameter is particularly important for electric vehicle users. It would be of great importance for the development of activities related to school, work, etc., are beginning to return to normal, so naturally, the traffic of cars is greater than what had been observed in recent years, hence the importance and relevance of this study, especially talking about a crossing as busy as the one studied in this research, in addition to abate pollution to the environment.

The creativity of this study lies in the fact that not only is traffic studied in terms of day and time, as expressed by; Kanawaty George, (1998), but also by including as variables of interest the direction in which automobile traffic flows: North to South and South to North along Avenida Río Chuvíscar, and Northeast to Southwest and Southwest to Northeast along Avenida Fernando Baeza; thanks to this, depending on the problem to be solved, a single direction can be selected, which is the one of interest for the question.

General objective

A general objective is one that indicates, in a global way, the purpose of the work to be carried out. It should be kept in mind throughout the research.

According to Arias Fidias (2006), a general objective expresses the concrete aim of the research in direct correspondence with the formulation of the problem.

According to Arias, the general objective is the one that gives meaning to the research, i.e. it is the one that defines the results to be obtained and the way in which it will be carried out in order to achieve these results. Therefore, the objective of this research is: To analyse the vehicular flow at the Fernando Baeza Avenue - Río Chuvíscar Avenue intersection. Applying the work sampling technique, with the aim of applying an improvement in road engineering to this strategic point.

Specific objectives

The specific objectives must be clearly expressed to avoid possible deviations in the quantitative research process and be achievable. According to Hernández et. al (2014), they are the guidelines of the study and must be kept in mind throughout its development, they need to be congruent with each other. To consider the contributions of the authors, subscribed throughout the research. These are mentioned below:

- Allocate the times at which the counting is to be carried out using the nomographic method and the random number table.
- Determine the synchronisation time of the traffic lights with the help of the stopwatch technique.
- Count the number of vehicles travelling in the four directions, i.e. north to south, south to north, northeast to southwest and southwest to northeast for five days at the intersection of Fernando Baeza Ave. and Rio Chuvíscar Ave.
- Construct (statistical tables), to record the results obtained in the sampling.

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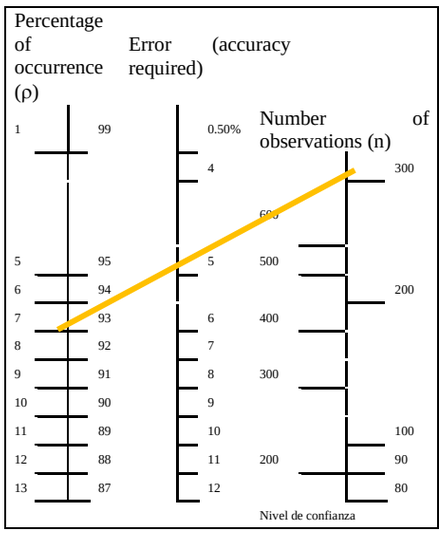

Table 1 Nomogram to determine the number of observations

49 54 33 54 82	17 37 93 23 78	87 35 20 96 43	84 26 34 91 64
57 24 55 6 88	17 4 74 47 67	21 76 33 50 25	83 92 12 6 76
16 95 55 57 19	98 10 50 71 75	12 86 77 58 7	44 39 52 38 79
78 64 56 7 82	52 42 7 44 38	15 51 0 13 42	99 66 2 79 54
9 47 27 96 54	49 17 46 9 62	90 52 84 77 27	8 2 73 43 28
44 17 16 58 9	79 83 86 19 62	6 76 50 3 10	55 23 64 5 5
84 16 7 44 99	83 11 46 32 24	20 14 85 88 45	10 93 72 83 71
82 97 27 77 81	7 45 32 14 8	32 98 94 7 72	93 85 79 10 75
50 92 26 11 97	0 56 76 31 38	80 22 2 53 53	86 60 42 4 53
83 39 50 8 30	42 34 7 96 86	54 42 6 87 98	35 85 29 48 39
40 33 20 38 26	13 89 51 3 74	17 76 37 13 4	7 74 21 19 30
96 83 50 87 75	97 12 25 93 47	70 33 24 3 54	97 77 46 44 80
88 42 95 45 72	16 64 36 16 0	4 43 18 66 79	94 77 24 21 90
33 27 14 34 9	45 59 34 68 49	12 72 7 34 45	99 27 72 95 14
50 27 59 87 19	20 15 37 0 49	52 85 66 60 44	38 68 88 11 80
55 74 30 77 40	44 22 78 84 26	4 33 46 9 52	68 7 97 6 57
59 29 97 68 60	71 91 48 67 54	13 58 18 24 76	15 54 55 95 52
48 55 90 65 72	96 57 69 36 10	96 46 92 44 45	97 60 49 4 91
66 37 32 20 30	77 84 57 3 29	10 45 65 4 26	11 4 96 67 24
68 49 69 10 82	53 75 91 93 30	34 25 20 57 27	40 48 73 51 92
83 62 64 11 12	69 19 0 71 74	60 47 21 29 68	2 2 37 3 31
6 9 19 74 66	2 94 37 34 2	76 70 90 30 86	38 45 94 30 38
33 30 51 26 38	79 78 45 4 91	16 96 53 56 16	2 71 50 95 98
92 38 97 1 50	87 75 66 81 41	40 1 74 91 62	48 51 84 8 42
96 44 33 49 13	34 86 82 53 91	0 52 43 48 85	27 55 26 89 62
64 5 91 95 86	11 5 65 9 68	76 83 20 37 90	57 16 0 11 66
75 73 88 5 90	52 27 41 14 86	22 98 12 22 8	7 52 74 95 80
33 95 2 75 19	7 60 62 93 55	59 33 82 43 90	49 37 38 44 59
97 91 40 14 2	4 2 33 31 8	39 54 16 49 36	47 95 93 13 30
15 5 15 93 20	1 90 10 75 6	40 78 78 89 52	2 67 74 17 33
22 35 85 15 33	92 3 51 59 77	59 56 78 6 83	52 91 5 70 74
9 98 42 99 64	61 71 62 99 15	6 51 29 16 93	58 5 77 9 51
54 87 66 47 54	73 32 8 11 12	44 95 92 63 16	29 56 24 29 48

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58 37 78 80 70	42 10 50 67 42	32 17 55 85 74	94 44 67 16 94
87 59 36 22 41	26 78 63 6 55	13 8 27 1 50	15 29 39 39 43
71 41 61 50 72	12 41 94 96 26	44 95 27 36 99	2 96 74 30 83
23 52 23 33 12	86 93 2 18 39	7 2 18 36 7	25 99 32 70 23
31 4 49 69 96	10 47 48 45 88	13 41 43 89 20	97 17 14 49 17
31 99 73 68 68	35 81 33 3 76	24 30 12 48 60	18 99 10 72 34
94 55 28 41 36	45 37 59 3 9	90 35 57 29 12	82 62 54 65 60

1er día 2do día 3er día 4to día 5to día

Figure 1 Random numbers
Source: Mancilla

Development

The method is applied to find out the automobile traffic at the Fernando Baeza-Av. río Chuvíscar intersection. Ten observations were taken per day, with a duration of three minutes. The data analysed were: number of cars heading north-south, south-north, northeast-southeast and southeast-northeast. For the sampling, with an error percentage of 5%, and with a confidence level of 95%, 300 observations were obtained, and five of the preset schedules are attached in tables 3, 4, 5, 6 and 7.

The 300 observations are carried out in 30 days, giving a total of 10 observations per day. They were carried out in 3 shifts of 5 hours: from 7:00 am to 10:30 pm. 5 hours is 300 minutes, so there are 30 periods of 10 minutes.

- Choose a random number from the table: 37
- Pick a number from 1 to 10: 3
- Going down the column, select a number from each 3 and write it down: 37, 69, 0, 66, 41, 10, 8, 94, 33 and 47.
- Eliminate 69, 66, 41, 94, 33 and 47 because they are greater than 30.
- Eliminate 37 because it is the initial number.
- Using the same procedure, select 7 more digits to replace the previous ones: 9, 14, 3, 4, 6, 24 and 26.
- Eliminate digits in case of repetition.
- Sort in numerical order: 0, 3, 4, 6, 8, 9, 10, 14, 24, 26.

(i) The smallest digit (0) represents 0°. Period of 10 minutes from the starting time.

Start of sampling	Multiplied by 10 min	Time of observation
0	0	7:00 + 0 = 7:00
3	30	7:00 + 30 = 7:30
4	40	7:00 + 40 = 7:40
6	60	8:00
8	80	8:20
9	90	8:30
10	100	8:40
14	140	9:10
24	240	10:50
26	260	11:10

Table 2 Timetables day 1, shift 1
Source: Own source

Start of sampling	Multiplied by 10 min	Time of observation
2	20	12:20
10	100	13:40
11	110	13:50
12	120	14:00
16	160	14:40
20	200	15:20
21	210	15:30
23	230	15:50
25	250	16:10
27	270	16:30

Table 3 Timetable day 1, shift 2
Source: Own source

Start of sampling	Multiplied by 10 min	Time of observation
4	40	17:40
5	50	17:50
7	70	18:10
15	150	19:30
16	160	19:40
23	230	21:50
24	240	22:00
27	270	22:30
29	290	22:50
30	300	22:00

Table 4 Timetables day 1, shift 3
Source: Own source

Start of sampling	Multiplied by 10 min	Time of observation
2	20	7:20
5	50	7:50
7	70	8:10
15	150	9:30
16	160	9:40
23	230	10:50
24	240	11:00
27	270	11:30
29	290	11:50
30	300	12:00

Table 5 Timetables day 2, shift 1
Source: Own source

Start of sampling	Multiplied by 10 min	Time of observation
3	30	12:30
6	60	13:00
10	100	13:40
12	120	14:00
16	160	14:40
18	180	15:00
21	210	15:30
23	230	15:50
26	260	16:20
27	270	16:30

Table 6 Timetables day 2, shift 2
Source: Own source

To carry out the sampling, 4 directions were taken into account: the section from Commscope to BBVA is considered to go from North to South, from BBVA to Commscope from South to North, from Alsuper to ADC Delicias from Northeast to Southwest and from ADC Delicias to Alsuper from Southwest to Northeast.

Sate: 25/03/22 Estudio: 1	Observador: M. L. O. I., A. E. P. L. y D. A. Q. P										Day 1	
Number of observations: 10 observaciones	16:30 hrs	17:00 hrs	17:10 hrs	17:30 hrs	17:50 hrs	18:00 hrs	18:10 hrs	18:50 hrs	20:30 hrs	20:50 hrs	Total	Percentage
North to South	15	9	15	7	11	13	10	2	14	14	110	11%
South to North	12	15	36	11	13	15	13	5	8	15	143	14%
Northeast to southwest	69	50	42	52	22	31	31	34	32	32	395	40%
Southwest to northeast	36	39	42	27	39	28	41	18	36	43	349	35%

Table 7 Sample example 1
Source: Own source

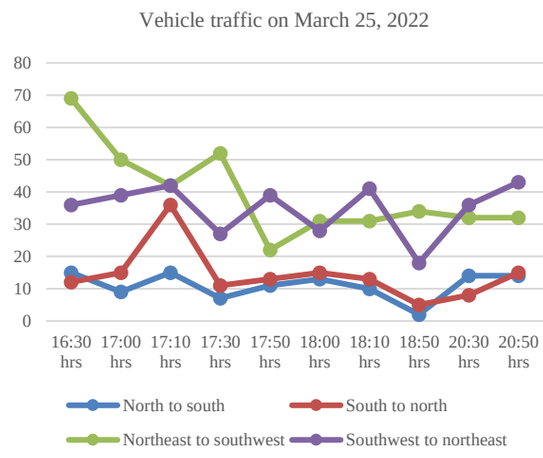

Figure 2 Sample example 1
Source: Own source

Based on the data obtained on 25 March (afternoon shift) on vehicle traffic, table 8 it can be seen that the busiest hours for each direction are: from North to South, at 16:30 hrs and 17:10 hrs, with approximately 15 cars; from South to North, the busiest hour is at 17:10 hrs, with 36 cars; in the Northeast to Southwest direction, the busiest hour is at 16:30 hrs with 69 cars; and finally, in the Southwest to Northeast direction, the peak hour is at 20:50 hrs, with 43 cars.

DATE: 26/03/22 Estudio: 2	Observador: M. L. O. I., A. E. P. L. y D. A. Q. P											Day 2
Number of observations : 10 observaciones	16:50 hrs	18:10 hrs	18:20 hrs	18:30 hrs	19:10 hrs	19:50 hrs	20:00 hrs	20:20 hrs	20:40: hrs	21:00 hrs	Total	Porcentaje
North to South	11	15	4	1	7	13	10	10	16	10	97	12%
South to North	9	17	6	10	4	9	10	9	16	7	97	12%
Northeast to southwest	36	40	29	15	15	26	26	19	27	25	258	33%
Southwest to northeast	44	37	26	20	24	32	39	45	34	25	326	42%

Table 8 Sampling example1
Source: Own source

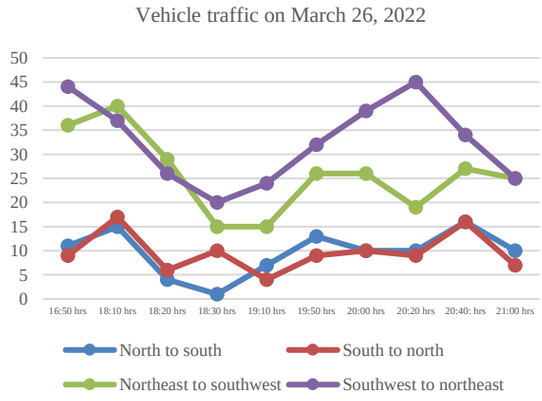

Figure 3 Sampling example 2
Source: Own source

According to the data collected on vehicle traffic on 26 March, table. 9, the peak hour of vehicular traffic in each direction studied is as follows: in the North to South direction this hour was at 20:40 hrs, with 16 cars; in the South to North direction, it is at 18:10 hrs, with 17 cars; in the Northeast to Southwest direction it is at 18:10 hrs, with 40 cars; finally, there is the Southwest to Northeast direction, in which the peak hour is at 20:20 hrs, with 45 cars; in the Southwest to Northeast direction, the peak hour is at 20:20 hrs, with 45 cars; in the South to Northeast direction, it is at 18:10 hrs, with 17 cars; in the Northeast to Southwest direction it is at 18:10 hrs, with 40 cars; and in the Southwest to Northeast direction it is at 18:10 hrs, with 40 cars.

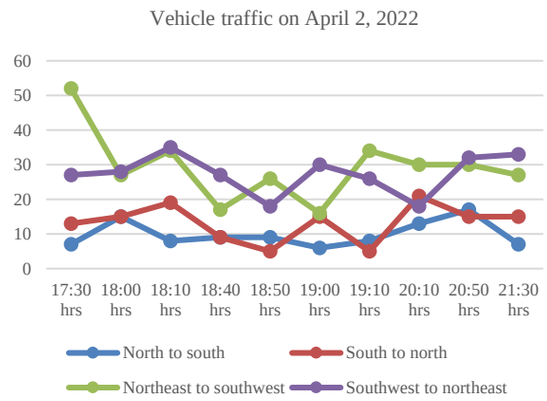

Figure 4 Sampling example 3
Source: Own source

DATE: 27/03/22 Estudio: 3	Observador: M. L. O. I., A. E. P. L. y D. A. Q. P									Day 3		
Number of observations : 10 observaciones	17:10 hrs	17:20 hrs	17:40 hrs	19:00 hrs	19:10 hrs	20:20 hrs	20:30 hrs	21:00 hrs	21:20 hrs	21:30 hrs	Total	Porcentaje
North to South	15	12	13	2	15	15	14	15	17	9	127	15 %
South to North	18	8	17	15	8	10	8	10	9	13	116	13 %
Northeast to southwest	30	21	31	10	20	20	35	30	30	22	249	29 %
Southwest to northeast	52	38	46	33	25	41	37	22	41	36	371	43 %

Table 9 Sampling example 3
Source: Own source

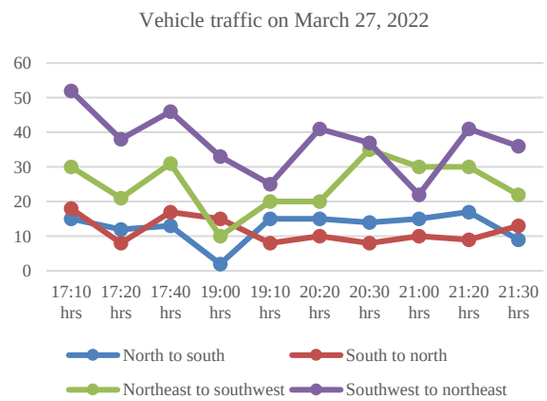

Figure 5 Sampling example 4
Source: Own source

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With the above, in table 10 the vehicular affluence of the day March 27, it is perceived that, in the 4 directions, the hours in which the vehicular traffic is greater are those that are described next: for the direction North to south, it is at 21:20 hrs, with 17 vehicles; the case of South to north, it is at 17:10 hrs, with 18 automobiles; for the direction Northeast to southwest, it is at 20:30 hrs with 35 vehicles: 20 hrs, with 17 vehicles; the case of South to North, is at 17:10 hrs, with 18 cars; for the Northeast to Southwest direction, it is at 20:30 hrs with 35 vehicles; and finally the Southwest to Northeast direction, at 17:10 hrs, with 52 cars..

DATE: 02/04/22 Estudio: 4	Observador: M. L. O. I., A. E. P. L. y D. A. Q. P										Day 4	
Number of observations : 10 observaciones	**17:30 hrs**	**18:00 hrs**	**18:10 hrs**	**18:40 hrs**	**18:50 hrs**	**19:00 hrs**	**19:10 hrs**	**20:10 hrs**	**20:50 hrs**	**21:30 hrs**	**Total**	**Porcentaje**
North to South	7	15	8	9	9	6	8	13	17	7	99	12%
South to North	13	15	19	9	5	15	5	21	15	15	132	17%
Northeast to southwest	52	27	34	17	26	16	34	30	30	27	293	37%
Southwest to northeast	27	28	35	27	18	30	26	18	32	33	274	34%

Table 10 Sampling example 4
Source: Own source

Based on the data in table. 11 on 2 April, the peak hours for each direction are as follows: in the North to South direction, it is at 20:50 hrs, with 17 cars; while in the South to North direction, it is at 20:10 hrs, with 21 vehicles; for the Northeast to Southwest direction, it is at 17:30 hrs, with 52 cars; finally, in the Southwest to Northeast direction, the peak hour is at 18:10 hrs, with 35 cars.

DATE : 03/04/22 Estudio : 5	Observador: M. L. O. I., A. E. P. L. y D. A. Q. P										Day 5	
Number of observations : 10 observaciones	**17:00 hrs**	**17:30 hrs**	**18:10 hrs**	**18:30 hrs**	**19:10 hrs**	**19: 30 hrs**	**20:00 hrs**	**20:20 hrs**	**20:50 hrs**	**21:00 hrs**	**Total**	**Porcentaje**
North to South	11	8	15	8	9	4	10	7	15	10	97	12 %
South to North	16	14	16	12	6	12	12	10	12	11	121	14 %
Northeast to southwest	47	50	36	20	20	19	26	25	30	26	299	36 %
Southwest to northeast	39	25	47	25	27	25	30	35	43	24	320	38 %

Table 11 Sampling example 5
Source: Own source

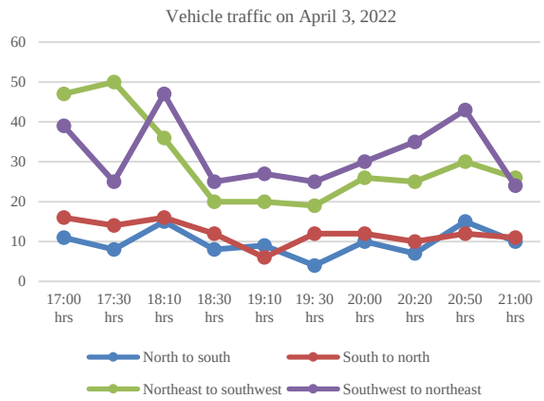

Figure 6 Sampling example 5
Source: Own source

Taking into account data from table. 12 for the sampling of the 3rd of April, on the vehicle flow, we have the following peak hours in the 4 directions observed: for the direction North to South, there are two different hours, and they are 18:10 hrs and 20:00 hrs: 50 hrs, with 15 cars; for the South to North, there are also two different hours, at 17:00 hrs and 18:10 hrs, with 16 vehicles; in the Northeast to Southwest direction, there is only one hour and that is 17:30 hrs, with 50 vehicles; and finally, Southwest to Northeast, at 18:10 hrs, with 47 cars.

Results

The following table 10 shows a general concentration of the data analysed during the sampling carried out, in order to reach a clear and well-founded conclusion on car traffic at the Fernando Baeza-Av. Río Chuvíscar intersection.

	North-South	South-North	North-East-South-West	Southwest-Northeast	Total
7:00–7:30	15	12	69	36	132
7:30-8:00	11	9	36	54	110
8:00-8:30	10	16	49	59	134
8:30-9:00	15	27	36	47	125
9:00-9:30	12	8	21	38	79
9:30-10:00	8	13	32	27	80
10:00-10:30	13	17	21	46	97
10:30-11:00	11	13	22	39	85
11:00-11:30	14	15	29	28	86
11:30-12:00	12	17	36	40	105
12:00-12:30	4	6	29	26	65
12:30-13:00	5	11	17	23	56
13:00-13:30	19	29	37	77	162
13:30-14:00	16	25	60	68	159
14:00-14:30	14	35	43	82	164
14:30-15:00	10	6	23	26	65
15:00-15:30	4	12	19	25	60
15:30-16:00	13	9	26	32	80
16:00-16:30	10	11	26	35	82
16:30-17:00	13	21	30	18	82
17:00-17:30	11	10	22	41	84
17:30-18:00	14	8	34	37	93
18:00-18:30	16	16	27	34	93
18:30-19:00	16	14	31	40	101
19:00-19:30	22	30	57	74	173
19:30-20:00	17	9	30	41	97
20:00-20:30	8	14	25	35	82
Total	**323**	**393**	**867**	**1178**	**2731**
Porcentaje	**10%**	**12%**	**30%**	**48%**	**100%**

Table 12 Concentrated data
Source: Own source

In order to create table 13 of the concentrate of the data obtained, the sampled schedules were compiled (daily registration tables see figure 7, which were created previously). To complete the filling of table. To complete the filling of table 13, the number of cars that travelled in the pre-established directions was also entered. For the schedules where more than one sampling had been performed, it was decided to average the data obtained on each of the days, as described by Hagen Kirk (2009), in case the result was a decimal number, it was rounded up to the next higher whole number.

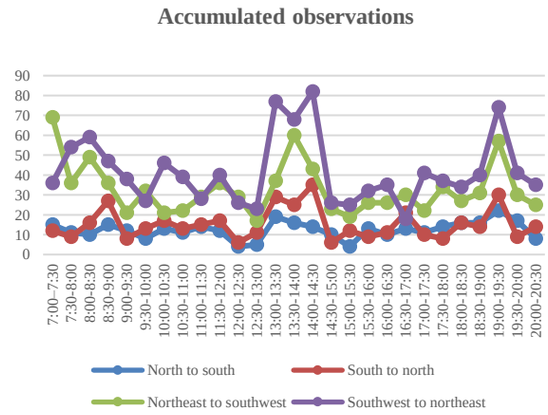

Figure 7 Data evaluated by hour
Source: Own source

After analysing the percentages in Fig. 7 and the graph, it can be seen that more cars travel from the Southwest to the Northeast, with a percentage of 48% of the total data sampled. According to; Rovetto, C., Cruz, E., Núñez, I., Santana, K., Smolarz, A., Rangel, J., & Cano, EE (2023). make reference that; Cities manage the different flows of cars at intersections in a static way, which makes the times assigned to traffic lights constant and not adaptable to changing traffic conditions at any given time, resulting in suboptimal performance. Given that a city has many intersections regulated by these systems, the inefficiency of these systems results in hundreds of hours wasted by citizens: This is because the Southwest part of the city has several subdivisions, so, when analysing an intersection that connects these subdivisions with a large part of the city (which is located to the Northeast), there is more traffic flow in this direction (Southwest-Northeast), which results in more traffic flow in the Southwest-Northeast direction).

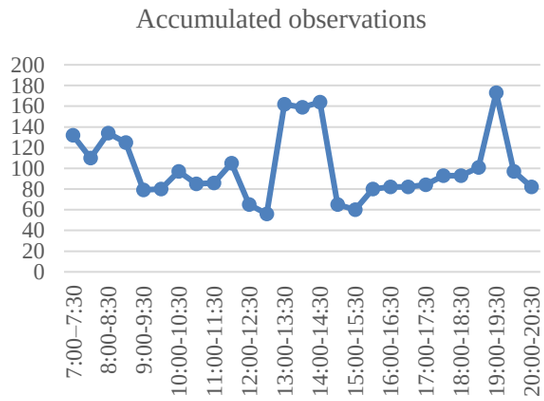

Figure 8 Data evaluated by hour
Source: Own source

It is also of interest to know the hours when there is more vehicular traffic at the Fernando Baeza-Av. Río Chuvíscar intersection, so the data for the total number of cars that pass through at the times analysed were also plotted, and it can be seen that the three times with the highest traffic flow between 7:00 and 22:00 hours are: between 7:00 and 9:00 hours, between 13:00 and 14:30 hours, and between 18:30 and 19:30 hours.

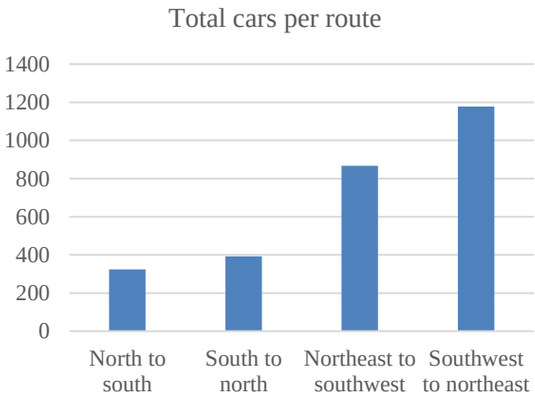

Figure 9 Data evaluated per route
Source: Own source

Conclusions

Following the analysis made in this fieldwork, a number of conclusions have been drawn. In order to present them more clearly, they have been divided into categories according to the context in which they were developed.

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Firstly, when sampling the Fernando Baeza-Av. Fernando Baeza-Av. Río Chuvíscar intersection, it was observed that the agglomeration that occurs in certain parts of the city can be measured thanks to analyses such as these. This type of analysis makes life easier, as it allows informed decisions to be made when travelling through the city in a vehicle. Importantly, this analysis can be applied to a myriad of activities, as pointed out by Mondal, S. and Gupta, A. (2023), related to a case study involving Shanghai that combines GPS-based bike sharing and road network data. First, spatio-temporal mobility patterns are visually analysed; then community sensing is used to divide the study area into management sub-areas according to mobility characteristics making it very technically functional. In addition, it was interesting to know that it is possible to identify the causes of congestion. And it is necessary to develop a road engineering focused on traffic lights at this strategic point. The application of this work sampling technique is of vital importance and its application is interesting. It is possible to have it in different areas, since they are very diverse places and have different purposes; from the traffic time that can be prevented when going to and/or returning from work to their homes, to being able to analyse the product that sells more in an establishment. This type of analysis not only yields a result, but also gives the possibility to act according to the information obtained, and in this way, to achieve technification by means of road technology.

According to; Palacios Acero Luis C, (2009), who mentions that the design in essence, is the solution of problems with methods that maximize the profit in the investment of time, money and other resources. a brief and general description of the characteristics of the problem, free of details and restrictions, includes at least: The input and output states: Another important possibility observed in this analysis study is the application of work sampling, which demonstrated the amount of analysis that can be done with a single sampling job; in this case, going to sample the number of vehicles transiting from North to South, South to North, Northeast to Southwest and Southwest to Northeast. It was of vital importance for both pedestrians and vehicle users to know the time of day when the most vehicles pass through the intersection, but it also provided more information, such as the direction in which there is the most traffic.

In general for any activity, work sampling is an engineering tool for continuous improvement of vital importance to determine the amount of time in activity or inactivity in a production process, since having established time standards helps to reduce labour costs, and also helps to improve areas of the company indirectly. Sampling results are used to determine tolerances or margins applicable to the work, to evaluate machine utilisation and to establish production standards, among other applications. To conclude, it is also interesting to note that there are already tools with established data for quality work, such as the nomogram.

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