Analysis and statistical projection of vehicle occupancy using average annual daily traffic in the city

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Abstract. The excess of both private and public vehicles has hindered the mobility of large cities and, likewise, has begun to affect small cities, increasing environmental pollution, accidents, mortality, among others. The following research work includes the diagnosis and projection to the year 2021 of the traffic generated in the road corridor for future constructions in the adjacent area of the tennis club of the city of "San José de Cúcuta, Colombia", through the collection of data by capacity of vehicles, traffic counts, surveys and vehicle registration, determining the present and future annual average daily traffic, within the main findings it was found that this sector is mostly traveled by cars, trucks and taxis. It was determined that the flow of vehicles will increase in the year 2021 by 24.62%, the constructions of shopping centers will be executed within the sector.

1. Introduction

As time goes by, countries have noticed that traffic congestion eventually worsens, harming frequent travelers (workers or visitors), therefore, in some countries they have taken measures that help improve vehicle flow such as: road construction, ticket management, traffic control, network balancing and purchase restrictions [1]. One of the countries with the highest rates of traffic congestion is the United States of America (USA), which in 2015 had 835 vehicles for every 1000 people, causing hearing and fossil fuel pollution and an increase in vehicle obstruction. This problem has caused travelers to lose time in long traffic lines and loss of productivity [2], a situation that the city of Yogyakarta experienced that year, with a 619.34 km highway and approximately 2.2 million vehicles [3].

The causes of traffic congestion are due to rapid population growth, which is not balanced with the development of road infrastructure, the conditions of existing roads that are affected over the years by meteorological factors, and vehicles crossing roads that exceed their capacity [4], harming those around them, and in turn creating environmental pollution, violence among users, loss of time, opportunity and frustration [5], in addition to blocking access roads for emergencies. Returning to the case of the sovereign country USA, it was announced that in 2011, only public transport had emitted approximately 14 million metric tons of carbon dioxide, for this reason, USA indicated the change from the private car, the purchase of efficient replacement vehicles that could reduce greenhouse gases [6]. In Malaysia, the drastic increase in vehicle volume from 2012 to 2014 was 11%, with an annual rate of 45%. This is proportional to population growth, which is expected to increase by 0.8% annually from 2010 to 2040, or 69% overall [7]. One alternative for improving vehicle flow and efficiency is the mobility reliability factor of the transport system, which focuses on the factors that influence reliability, such as travel time, speed, system capacity and usage, so that it can reduce traffic congestion [8].

The Development Plan for department of Norte de Santander, Colombia, envisages that the department will be competitive in the economic sector, socially equitable, administratively efficient, territorially more ordered and with better living conditions [9]. In accordance with this, it is important to carry out a detailed study of the current situation of any sector and to be able to propose alternatives that will reduce the crisis in mobility, pollution, vehicle stress and improve productivity, competitiveness and development. 6% over the previous year in Colombia [10], mainly due to the increase in the number of foreign vehicles in the city, which is on the border with Colombia, affecting vehicle traffic [11].

The present work analyzes the weekly vehicle movement of the roads, projecting the vehicle flow for 2021, by means of the equation of average daily traffic, relating the variables of the vehicle flow (volume, time intervals, type of vehicles and the annual accumulative growth rate of vehicle traffic) based on the data collection of 6 days by 15 hours daily of the sector with high mobility of the roundabout "Virigilio Barco" and roundabout "Padre Garcia Herreros", showing that the volumes will grow in 5 years in 24. 62%, due to its macro growth of the commercial and housing sector.

2. Methodology

This project focuses on diagnosing the current situation of the avenue and projecting the future situation of the sector through urban and commercial projects, using information collected from different entities [12], through direct observation, traffic counts, vehicle capacity, photographic records and surveys of the sample that uses the road corridor for 6 days and 15 hours a day. Average annual daily traffic (AADT) is used as a predictor of accidents, road construction and noise exposure estimates [13], to calculate the transit projection starts by calculating the present transit with Equation (1).

$$\text{AADT "0": } = \frac{(\text{Number of vehicles in a year})}{365 \text{ of the year}}. \quad (1)$$

Later, the projection is calculated with Equation (2). F is found, being the future transit in a certain year, P is TMDA in the year 0 (present transit), in the annual cumulative growth rate of the transit and n the time of the forecast in years.

$$F = P(1 + i)^n. \quad (2)$$

3. Results

3.1. Roadway corridor peak hours

In Figure 1 and Figure 2, the number of vehicles vs. hours studied from data collection is represented. The flow of vehicles is irregular due to the fact that the "Santo Angel" school is located on this road, which has two study days and the students leave between 12:00 and 13:00 (morning day) and from 18:00 - 19:00 (afternoon day). It can be seen that there is no maximum demand for the roadway in the morning, despite the fact that the time from 5:00 to 6:00 is the entry time for the morning session at the school. The hours with the highest vehicle demand presented from the week of May 14 to 20, from the direction of roundabout "Virigilio Barco" and roundabout "Padre Garcia Herreros" are as follows: 12:00 to 13:00; from 14:00 to 15:00 and from 18:00 to 19:00 and from the direction of "Padre Garcia Herreros" roundabout to "Virgilio Barco" roundabout: 12:00 to 13:00 and 18:00 19:00.

3.2. On days of peak demand in the roadway corridor

In Figure 3 and Figure 4, we analyze the days of the week vs. the amount of vehicle demand according to data collection in both directions, highlighting a constant amount from Monday to Wednesday and decreasing substantially from Friday to Sunday, due to class inactivity. The days with greater vehicle demand presented from the week of May 14 to 20, from the roundabout "Virgilio Barco" to roundabout "Padre Garcia Herreros" are during the hours of study from Monday to Friday varies from 12000 to

14000 vehicles and decreases substantially over the weekend, while in the direction of the roundabout "Padre Garcia Herreros" to roundabout "Virgilio Barco" a similar behavior to the lane in the opposite direction is registered, but with fewer vehicles ranging between 10000 and 12000 and equally for the weekend the number of vehicles also decreases.

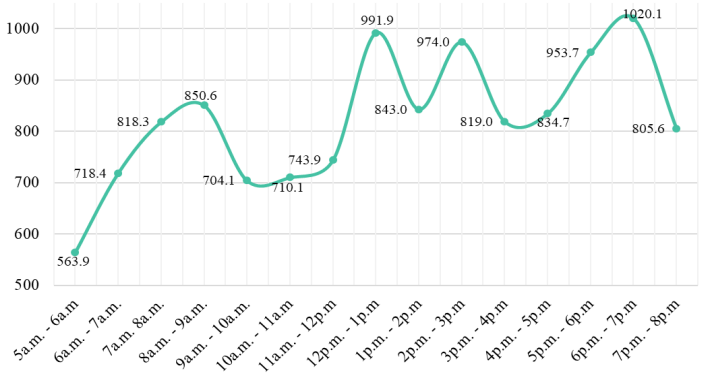

Figure 1. Number of vehicles vs. hour. Direction from roundabout "Virgilio Barco" to roundabout "Padre García Herreros".

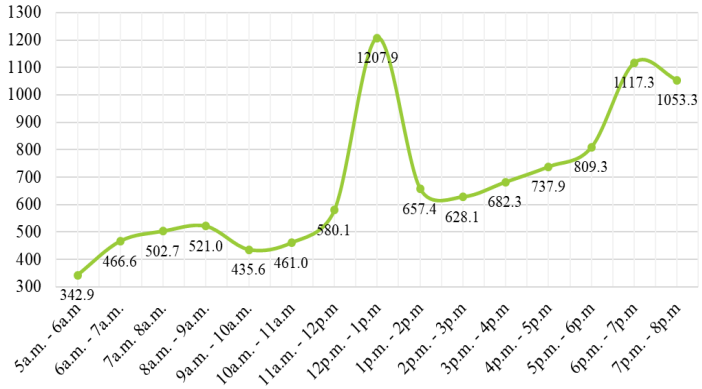

Figure 2. Number of vehicles vs. time. Direction from roundabout "Padre García Herreros" to roundabout "Virgilio Barco".

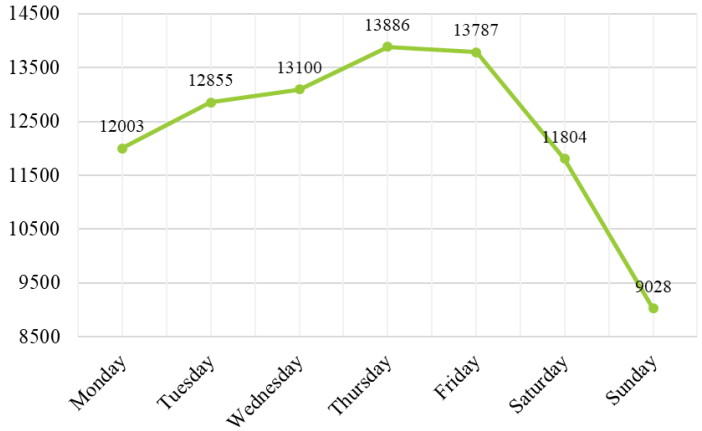

Figure 3. Number of vehicles vs. days of the week. Direction from roundabout "Virgilio Barco" to roundabout "Padre García Herreros".

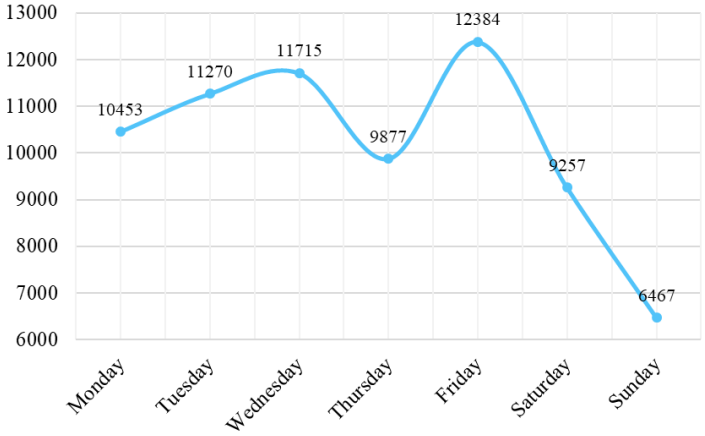

Figure 4. Number of vehicles vs. days of the week. Direction from roundabout "Padre García Herreros" to roundabout "Virgilio Barco".

3.3. Vehicle type in both directions

In Table 1, these are the results of the collection of the information regarding the types of vehicles and their quantity at the time of observation. A high concentration of delays was observed at multiple points along the route, associated with congestion on the stretch during the study period. During the off-peak hours, the road infrastructure at the study site presents characteristics that favor the development of high speeds, even above the permitted speed limit. The basic causes of stops and delays along the route are vehicle congestion on the road, the rise and fall of passengers in vehicles and the parking of vehicles in places not considered for this purpose, especially in the area corresponding to the "Santo Ángel" school.

Table 1. Vehicle type vs days.

Roundabout "Virgilio Barco" to roundabout "Padre García Herreros"								
Vehicle/Days	14	15	16	17	18	19	20	Average
Automobile	5270	5160	4587	4187	4398	4304	3839	4535
Camper	0	0	0	1	0	1	0	0
Taxi	1750	1970	2013	1110	1274	1655	1769	1649
Pick-up truck	3738	3976	3890	2346	2068	2342	2393	2965
2-axle truck	1090	2290	2390	2334	2445	2360	3102	2287
3-axle truck	246	284	375	401	363	309	262	320
4-axle truck	10	23	9	7	6	12	13	11
Buses	0	2	1	1	1	0	2	1
Omnibus	84	101	108	87	104	103	92	97
Roundabout "Padre García Herreros" to roundabout "Virgilio Barco"								
Automobile	3861	3326	3573	3928	4021	3184	3002	3556
Camper	0	1	1	0	0	0	1	0
Taxi	1429	1511	1285	1303	1368	1211	1289	1342
Pick-up truck	3214	3456	3612	3023	3848	2722	1905	3111
2-axle truck	1099	1852	1990	1300	2050	2360	2020	1810
3-axle truck	118	241	183	297	265	171	151	204
4-axle truck	23	30	26	35	34	22	8	25
Buses	5	12	10	11	4	5	12	8
Omnibus	21	7	18	12	24	15	10	15

The vehicles that circulate in the direction of the roundabout "Padre Garcia Herreros" to roundabout "Virgilio Barco", are delayed more than the time, in the hours of greater demand, of which they would have to be delayed if the conditions of the vehicle flow were more stable, this because in this direction

is the "Santo Angel" school. In the different types of vehicles that circulate on the road, it can be observed that the time of delay, in the hours of greater demand, exceeds in all the cases the time of march, in direction to the roundabout "Padre Garcia Herreros" to roundabout "Virgilio Barco", which indicates that the vehicles that circulate by the route remain more time stopped than advancing, this because in this direction is the "Santo Angel" school.

3.4. Traffic projection for 2021

Table 2 projects the number of different vehicles moving in 2021, calculated by Equation (2), by choosing growth rate (i) with 4.5% and a projection n of 5 years for its initial date of April 2016.

Table 2. Projection of future transit 2021.

	Roundabout "Virgilio Barco" to roundabout "Padre García Herreros" (1)		Roundabout "Padre García Herreros" to roundabout "Virgilio Barco" (2)	
Vehicle	P (1)	F (1)	P (2)	F (2)
Automobile	4535	5651	3556	4431
Camper	0	0	0	0
Taxi	1649	2055	1342	1637
Pick-up truck	2965	3694	2341	2917
2-axle truck	2287	2850	1810	2255
3-axle truck	320	399	204	254
4-axle truck	11	13	25	31
Buses	1	1	8	10
Omnibus	97	121	15	19
Total		14785		11591

4. Conclusions

Within the project it was possible to verify that both the road corridor located between the roundabout "Padre Garcia-Herreros" to roundabout "Virgilio Barco" and in the other direction, the vehicle congestion is an average of 11140 vehicles daily average, during a period of working days and likewise the corridor located between the roundabout "Virgilio Barco" to roundabout "Padre Garcia-Herreros" presents an average of 13127 vehicles daily average; which leads us to dimension the high level of congestion that is presented in that corridor. In the same way in a similar period to the previous one, but with the incidence of not developing school activities, the schools that are located in that sector have an average of daily vehicles of the order of 5287 and 7543 respectively. It is concluded that this sector is highly projected to obtain a macro development, as much in the habitational as in the commercial thing, this given to projects of towers of apartments that are in their phase of approval of licenses of construction, like the projection of a commercial center. According to the projections of future traffic calculation, for a period of 5 years a growth has been established in the road corridor located between the roundabout "Virgilio Barco" to roundabout "Padre García-Herreros", an increase in the average daily traffic of 11864 vehicles (2016) to 14785 vehicles was observed, concluding with an increase over this corridor of 24. 62% and in the roundabout "Padre García-Herreros" to roundabout "Virgilio Barco" with an average daily increase of 9301 vehicles to 11591 obtaining an increase of the same proportion to the previous result, being cars the first means of transport with greater mobility with 38.22% and vans with 25.17% for 2021, consequent of its increase with respect to 2016.

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