



# Analysis of Road Service Demand Through Vehicle Flow Modeling

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**Abstract**— The reduction of the efficiency of road projects in Ecuador, in the context of evaluating vehicular flow and the demand for cutting-edge technology. Since vehicle flow modeling is imprecise, it is important to recognize that this situation denotes the need to use new technological and innovative methodologies. Unmanned aircraft (Drone); allow the behavior of moving objects to be observed in real-time, being a novel research technique that allows data to be obtained effectively, efficiently, economically, and less invasively. In the investigation, the aforementioned equipment was used with a flight duration given between 25 to 30 minutes; in addition, the vehicle content files allowed the information to be processed in a systematized way with digital exclusivity, recognizing that both the information of the technological method and in the traditional, record at 15-minute intervals. The methods allowed to determine the demand for road service; however. The research recognizes the importance of studying the participants within the movement and strengthening street culture, both in the pedestrian and the user.

**Keywords:** Technology; non-traditional vehicle capacity; vial solution

## I. INTRODUCTION

THE decrease in the efficiency of road projects is the research problem; its study is important because of the effects it produces; affecting society, the economy, and the environment. The use of technology would increase the efficiency of road projects. Based on the experience acquired in traffic engineering, it has been noted that the application of technology is necessary and convenient, so this research work is committed to taking advantage of the benefits that cutting-edge technology offers us. This time, we focus on using unmanned aircraft to explore more of the possibilities acquired on the site from the application results that allowed the achievement of the objectives and the solution to the problem.

During the investigation, it is possible to determine the efficiency in terms of the performance of the study. Depending on the vehicular flow, given the circumstances of the new normality of covid-19 in Ecuador, which as a reactive measure raised the vehicular restriction through the last digit of the vehicle plate. Given this situation, the investigation was carried out on specific days: Monday, Wednesday, and Friday, from October 12 to 16, 2020, to study vehicular flow close to the local reality. Due to the provisions made by the government entities, it is important to highlight what was done during the capacity days, in which the vehicular flow was exposed as expected, where there were intermittent flows that were reflected as cycles of low and high vehicular demand. Most of the vehicles that passed through the intersection were classified by their type: a) A, b) B, c) C1, d) C2, e) C3, and f) C4.

On the interstate highways that make up the road network of the Ecuadorian territory, road accidents have occurred. Giving rise to the general discomfort of the population that lives near the sectors where the events occur, these, in turn, have sought answers to understand why they happened; of course, these have not been attended in the best way. So here comes one of the main questions; what causes traffic accidents? We know that the answers could fall into a large group of various reasons; however, in this research, a more innovative approach was chosen, an approach with a projection towards the use of technologies that respond to said question mark. In relation to the collection of information on the E-482 road, the record of road accidents that occurred during the years 2019 and 2020 was obtained as official data; the investigation recognizes the statistics of the Ecuadorian Transit Commission (figure 1), specific to road E-482 in the cantons: a) Nobol, b) Lomas de Sargentillo, c) Isidro Ayora, and c) Pedro Carbo, at an approximate distance of 30.2 km.

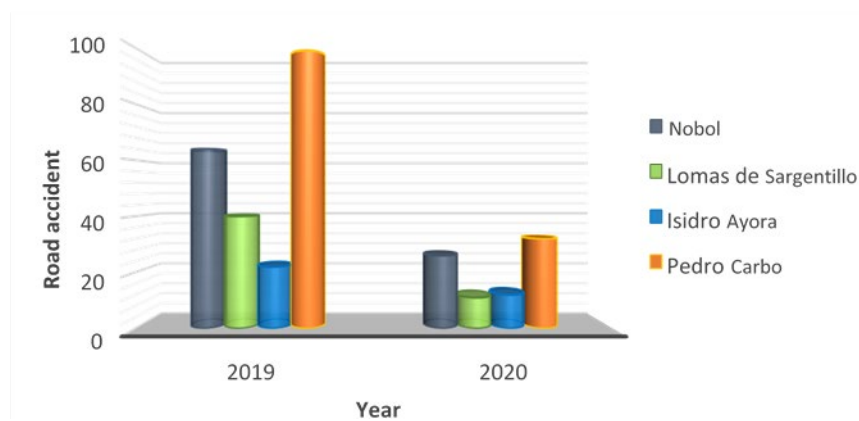


Figure 1. Accidents that occurred on the E-482 road in the years 2019 and 2020 with a cutoff in August 2020. Source: Ecuadorian Transit Commission.

Strategies and actions focused on reducing accidents in cities have generated favorable results; however, some cities have not experienced the same, which allows us to recognize that road accidents respond to the strategies and actions adopted in the territory. The use of technological tools in the efforts of the cities that show an improvement in the reduction of automobile collisions is evident. In this way, obtaining information plays an essential role in the decisions that are going to be taken for the benefit of mobility. Likewise, it is appropriate to refer to the actions carried out with a quantitative approach based on measurable records and justified.

According to Candia [1], in the road environment with the use of technologies (Drones), physical characteristics, movements, or behavior patterns are observed on the roads at certain times of the day, categorized as a peak. The traditional techniques used by agencies and entities in the road sector to collect information and subsequently manage traffic differ in two methods: a) Intrusive methods (for example, inductive loops embedded in the pavement, tubes/hoses, etc.), and b) The non-intrusive ones, which are typically located mounted on elevated structures (e.g., cameras, radars).

By pointing to the use of technologies that speed up the process of obtaining information, it is necessary to have data attached to the reality that will be reflected as a proposal for a solution. For example, unmanned aircraft, also called drones, can carry out autonomous flights with the use of an application used for real-time visualization. Despite this, the presence of an operator fulfills the function of intervening and regulating the parameters that the controller application will modify.

## II METHOD

The research will be oriented towards observation, for which manual and autonomous instruments will be used. Giving reliable results regarding the situation to be evaluated, such as the use of unmanned aircraft (Drone) and the application of modeling software; called Synchro 8, while the approach that will prevail will be quantitative because it is a question of procedures based on measurements, results that will be of great importance to determine the level of service and the capacity index of the road as the main objective.

In the elaboration of the work plan, the section that includes the urban area of the Isidro Ayora canton, specifically on Av. Juan Montalvo (E482) was recognized as a study area. From here, the mobility patterns with the highest vehicular load were identified, data that is intended to be obtained from the vehicle counts, and for the purpose of these counts, an estimated date should have been set to collect reliable figures, a scenario that was forced as a result of the declaration of a health emergency on March 17, 2020, where one of the effects caused by the vehicular restriction, reflecting a considerable decrease in the mobility of the cities, as time passed without the presence of vehicles on the roads, in the month of August the measures were normalized in the face of the need to improve the local economy of cities that were affected by the low commercial activity, in this way for the month of October the decision was made to set a start date for the works Research garlic, being selected on October 12, 14 and 16, 2020, with a day that started from 07:30 am to 06:30 pm.

One of the main reasons that led to the realization of this work was the use of technology in road projects, which aims to continue with this environmentally friendly approach; during the execution of the data collection process, it is intended to use drones with the sole purpose of observing from a perspective in greater detail and promoting innovation in similar projects.



Figure 2. Techniques and instruments used in the investigation. Author Presentation

The aforementioned avenue has a very particular geometry, where its variables range from widths of the road, lengths of access, and road signs to behavior in the directions of the road. It is also due to indicate that vehicular flows are intermittent during the daily shift; these flows sometimes tend to generate congestion as a result of the entry and exit of heavy and extra-heavy vehicles from the main road to the smaller road and vice versa.

For the analytical process of the study, it was decided to distinguish the phases of the investigation; the first phase includes the use of technological tools to obtain the required information, followed by an event; it is the processing of the data in the Synchro 8 software to later expose through modeling the virtual recreation based on the entered values, and that allows us to visualize the effects caused in terms of the behavior of the scenario.

#### ***Phase 1 – Use of technology/Collection of information***

In this phase, the necessary data will be collected for the interpretation and analysis of the situation that occurs on the E-482 road (Av. Juan Montalvo). In effect, the tools used were specifically unmanned aircraft; this technological device gave us considerable help in aerial observation, thus leading the investigation to an innovative approach, being a tool that is rarely used in the field of traffic engineering. From here, it was possible to visualize which vehicular flows break into the development of the correct mobility of the sector.

According to Flores, the importance of correct registration, storage, and monitoring of information associated with road accidents is key to decision-making in areas as diverse as Health, Traffic, and Insurance, among others. This would represent a significant help when determining which are the most recurrent causes that are reflected in the high accident rates. [4].

Being an innovative device for the elaboration of the work plan in the field, the use of a GoPro-type sports camera resistant to the high temperatures to which daily traffic is exposed was also required; the use of the device was very useful since it has the ability to capture frames with a comprehensive visual range, this function was used because in this way all kinds of details were streamlined and reviewed, knowing that the opportunities to visualize the behavior of the vehicles were endless.

#### ***Phase 2 – Software Application/Data Processing***

For the processing of the data obtained, it was necessary to adopt as part of the investigation the generation of results, the use of specialized software in virtual modeling from the geometric layout, field conditions, flow behaviors, and type of signaling. All these functionalities are part of the composition and tools offered by the Synchro 8 Student Version Software.

The use of artificial intelligence to carry out simulations is a proposal to get closer to a solution that implies integrating the geometry of the road, the vehicular flow, and the geographical conditions of the environment, to support the idea of using tools that provide results based on to the simulation, updated and specific information will be obtained from ICT.

Based on the values entered in the lane configurations section. It should be specified that these were gathered from field research. Therefore, it is essential to define the hourly volume of maximum demand (VHMD), peak hour factor (FHP), lane widths, and the location of traffic control signs to analyze the road based on its performance.

### **Phase 3 – Modeling/Results**

For the sample of results, it was necessary to elaborate virtual modeling of the vehicular behavior observed in Av. Juan Montalvo, the modeling was carried out with the values registered, representing the greatest impact on mobility during the days 12, 14, and 16 of October 2020; in this way, all results generated by the software will be based on the generation of the data obtained.

Celis mentions that the use of artificial intelligence applied in autonomous systems that carry out simulations with results subject to interpretation from the collection of information is one of the tools that has gained strength compared to the already known traditional techniques [3]. Currently, this technology is subject to free access for its manipulation or correction, which, based on algorithms, execute actions based on the vehicular flow intended to be evaluated.

The Synchro 8 student version software presents variables that will be decisive in making decisions for the execution of road projects; the actions carried out based on the established criteria for carrying out the modeling, is to demonstrate how efficient and beneficial the application is, the which, apart from being innovative, is widely used in projects with a great impact on the mobility of developed cities.

### **III. RESULTS**

After carrying out the virtual modeling, the number of vehicles that circulated through the gauging point was quantified; in this way, the volumes of maximum hourly demand, peak hour, annual daily average traffic, and the useful capacity index of the road, in order to determine how efficient, the road under study is in the coming years.

From the fieldwork, it was shown that Av. Juan Montalvo) has two lanes in each direction with a total width of 23.96 meters, including side sidewalks and a central flower bed within the urban perimeter of the Isidro Ayora canton, two accesses that are integrated into the road E-482, these have a considerable vehicular load since from here the entry and exit of at least 2125 Veh/day between light, heavy and extra heavy vehicles were registered.

As a fundamental part of the investigation, we must mention that the review of the results is due to specific and specific analysis; in this instance, the reason for the process after the restart of mobility activities in the Ecuadorian territory is highlighted due to the declaration of emergency given In March 2020 due to covid-19, after approximately seven months of mobility restriction had elapsed, the gradual increase in vehicular traffic was evidenced, a necessary reason to schedule the possible dates that will be key to the development of the investigation.

It should be clarified that the results of the investigation are specifically related to the provisions of the Highway Capacity Manual [2]. The added value is supported by the correct use of the roads and the proper use and importance of urban mobility. So, if we proceed with the analysis of the results, we can indicate that Av. Juan Montalvo has justified daily traffic, which, adding the two directions that make up the east road, borders on 12,315 Veh/day; this figure considerably influences the development of the vehicular behavior in an evolutionary way since the behavior of the flow is shown to increase as the days and hours vary, in addition to this we can indicate that the flow under analysis lends itself to being called intermittent or moderate, corresponding to the figures that detail it as such.

Likewise, the results corresponding to the hourly volumes of maximum demand for each direction are shown on the different days of the week in which the vehicle capacity was carried out; in this way, we must indicate that for the VHMD with the highest demand it was the one that was registered. On Monday, in the West direction with 492 Veh/h and in the East direction 473 Veh/h, these values represent the periods of maximum demand on a particular day.

The annual average daily traffic in each direction is detailed as follows:

- TPDA Av. Juan Montalvo westbound = Monday (5464 Veh), Wednesday (4983 Veh), Friday (4841 Veh).
- TPDA Av. Juan Montalvo eastbound = Monday (5250 Veh), Wednesday (4930 Veh), Friday (4929 Vehicle).

Through the modeling, questions that arise from the problems that have repeatedly arisen on the roads that make up the road network of Ecuador were cleared up. Unfortunately, those doubts are synonymous with the scarce utility and obtaining of data referring to the behavior of vehicular flows whether on a road, avenue, highway, or some intersection.

### **Traffic Report – Synchro 8**

The report generated by the Synchro 8 software exposes the results obtained by means of which the necessary values are established for the analysis of the specific situation, and the data entered in the configurations for each lane are described in such a way that the interpretation of the same must be understandable and concise. In addition, it should be mentioned that the turns made from the main road to the north and south have been considered.

It is essential to state that the data shown corresponds to the composition and classification for each type of vehicle that circulated on Av. Juan Montalvo corresponds to the days on which the data collection process was carried out. In the graph it can be seen that the traffic is composed in the following order: a) 75% light vehicles, b) 12% 2-axle heavy vehicles, c) 7% Buses, d) 4% 4-axle heavy vehicles, e) 1% 3-axle heavy vehicles and f) 1% 5-axle heavy vehicles.

The average speed of the vehicles that travel along the road turned out to be calculated initially through modeling, giving an estimated value of 62 km/h, a relevant fact that was corroborated in practice with the use of a light-type vehicle.

Knowing that the E-482 road crosses the urban area of the Isidro Ayora canton from east to west, the commercial and economic growth of the canton is directly influenced by Juan Montalvo avenue; for this reason, it is necessary to indicate that the speed control in the avenue fits what the present research work seeks.

### **Track useful capacity index**

As stated at the beginning of the investigation, executing the modeling and obtaining the expected results is intended to determine the capacity index offered by the road in such a way that said value is obtained through post-field work, knowing that in every project road it is necessary to know what the service level of the road will be, we must reject what is the future projection of the growth of the road due to the absence of records prior to the execution of this report. If it is the case to collect the necessary information, a work plan will be framed that responds to the need to estimate the growth rate on the road. For now, our sample results are presented as a minuscule part of the extensive development that is needed for a projection.

## **IV. DISCUSSION**

In Ecuador, there have been road projects in which the use of traditional techniques is common; despite obtaining data on the situation that occurs in each project, these do not generate reliability in relation to what the problem manifests; with this, we do not try to disfavor the methodologies chosen in said processes, even more so knowing that it is the basic principle of the investigations that were carried out for the common well-being of road users; instead, it is intended to introduce and complement the actions that produce positive results and that they argue the criteria in decision making.

If we make a comparison regarding the way of obtaining information in the field for road projects, on the one hand, we have the traditional method known as a process that contemplates the collaboration of at least four people (gauges) in data collection; let's add to this that the coordination of said group must be in charge of a leader and the analysis of these data under the control of a person who knows about the management of some technological tool that allows developing skills for the generation of results.

On the other hand, the idea of innovating in the processes that are born from known models to a non-traditional methodology is supported, for it is decisive to point out that the aforementioned methods will have points in common, which is precisely the outcome of the development of the results and how it was obtained by applying technological tools in research.

For this investigative process, it is intended to promote an alternative supported by a non-traditional method, which estimates to reduce operating expenses and increase the efficiency of obtaining information; in addition, it is expected to promote the use of technologies for the development of activities that originate in the roads and that are directly related to the situation that the world has been experiencing for the last nine months since the start of the pandemic due to covid-19.

Although it is true, regarding the activities that were intended to be carried out in the months before declaring the state of emergency in Ecuadorian territory, the methodology to be used consisted of the use of research tools and techniques carried out by human personnel in the field. , having direct exposure to the circulation of vehicles and the presence of pedestrians, this changed at the moment due to the uncertainty and the fear of acquiring some type of disease due to possible contagion.

During the days in which the information was collected, the use of technologies played an essential role in the investigation; the use of unmanned aircraft and the use of sports cameras with a wide angle view provided a significant scope for the quantitative results. Which were subsequently demonstrated in virtual modeling, thus leading a line of research framed towards the improvement of obtaining processes for a road solution.

In the same way, it was possible to define that Av. Juan Montalvo presents us with a flow with a variable vehicular intensity, where there are hours of low and high demand. Given the need to control the flow in an orderly manner, vehicular behavior was more noticeable during peak hours, in such a way that the capacity reached 489 vehicles in 4 cycles of 15 minutes, corresponding to 1 hour in the lanes. For greater circulation, despite the fact that the current regulations do not contemplate this value as a minimum requirement, it is important to highlight that road safety for pedestrians must be above all else; therefore, if the intention is to implement traffic light equipment as a solution in some of the intersections that are conflicting, the possibility of arguing the technical criterion should be evaluated based on what the current regulations indicate. If we take stock of the activities carried out in the field, we will find variables that were favorably involved in the proposal to take advantage of technologies in gathering information for road projects; however, quite apart from benefiting the researcher, this option promotes a set of actions that become non-invasive techniques in the development of information search activities in urban mobility.

It is unpredictable to determine how efficient the proposed method is since it depends on the climatic conditions in which the fieldwork will be carried out; in view of this, we must point out that in the winter season, where the climate tends to present precipitation (rain), the use of drones is not recommended, unless it is easy to operate with an industrial-type aircraft, which must meet the minimum standards for IP66 certification.

According to Cabrera, the importance of recognizing more specifically which, when, and where traffic signs should be installed should be subject to complete analysis of the need to reduce road accidents. For this reason, it is important to carry out a correct survey of information on the situation according to the external factors that influence the problem [5].

## V. CONCLUSION

Based on the investigation carried out on Av. Juan Montalvo (E-482), the following points are presented for evaluation:

- Strategies and techniques were used that allowed to reduce the time in the collection of information regarding the geometric characteristics and traffic conditions of the road under analysis; because direct measurement and technology combined with systematized processing constituted what would be an effective method with respect to obtaining results.
- The level of service and the capacity index of the road were determined by means of its geometric characteristics and the behavior of the vehicular flow in terms of speeds, times, quantity, and category. The information was processed in the free access software Synchro 8.
- It is concluded that the road develops 53.9% of its capacity under normal conditions, which allows us to recognize that it has optimal use in terms of its capacity; because the maximum daily vehicular volume on Avenida Juan Montalvo (E482) was recorded on Friday, October 16, 2020, with 12,315 Veh/day. In addition, the conditions obtained regarding service levels and in support of what is specified in the Highway Capacity Manual [2]; allow us to determine that the road is type A, which means that it is important for the development of the Isidro Ayora canton.
- It was visualized that in the section that includes Av. Juan Montalvo, within the urban area of the Isidro Ayora canton, there are access routes that intersect with the aforementioned road, causing changes in traffic during the so-called peak hours, being one of the most significant the intersection with the road to Mercedes.
- The need to incorporate a traffic light was identified at the intersection with the Via a las Mercedes, given the braid effect in the current vehicular lines, which could be observed through modeling. The Synchro 8 software manages to model the different possible scenarios to be experienced on the road under study, an event followed by the identification and evaluation of traffic problems, which are again recognized as a cause and effect of the lack of signaling.
- It was observed that in the three days of capacity, the presence of pedestrians who make use of the crossings, for example, at the intersection with the road to Las Mercedes, does not exceed 20 people/hour; this explains the situation regarding the low and intermittent influx by users on the road (pedestrians) against the mobility restriction due to covid-19 that occurred in the months prior to the study.
- It was determined that the flow demand is accentuated with a greater presence of vehicles on Wednesdays and Fridays, considering the peak hours, which allows us to identify that during the week, the vehicular flow is intermittent. The vehicular flow denotes the particularity of a dynamic development; because different cycles were observed in which the increase and sometimes decrease in the presence of vehicles during the day was evidenced.
- The vehicular flow was recognized from a different perspective as continuous; that is to say that it presents constant speeds, a condition that, together with the defined typology, highlights that the comfort and convenience offered to the user can be considered excellent. However, it is necessary to specify that in the face of these benefits and qualities, problems were detected around the lack of signaling at their intersections, as previously stated.
- It is concluded that the strategic selection of the control points allows zoning in order to cover the pertinent space for the development of field activities. In addition, it facilitates the intervention of research instruments, unmanned aircraft, such as the one used in the study.
- Advantages are distinguished in the application of the static camera with wide angle vision in obtaining audiovisual information; It considerably improves research in terms of its development and operation because the lack of independence of unmanned aircraft is made up for since the lack of batteries was experienced.
- It is determined that the proposed method should be regulated in the information gathering process through the different uses assigned to the chosen tools; For example, a drone cannot be exposed to continuous use for 3 hours due to the lack of batteries and the heating of its electronic components; without prejudice to the benefits that this tool offers us.

## VI. RECOMMENDATIONS

- Control vehicular traffic by means of a system made up of devices and a specific time schedule or a series of established schedules accompanied by devices for pedestrian crossing.
- Implement traffic light equipment at some of the intersections that present accessibility conflicts with the main road, considering the feasibility through technical, social, and economic parameters for its execution.

- Analyze the state of public lighting so that; accidents, including road accidents, are reduced. The comments are based on field observations, given the absence of lighting at certain intersections, which puts the pedestrian who interacts with the user at risk.
- Motivate the regulatory entity that has strict competence in traffic matters, estimating the commitment to road safety in such a way that the installation of vertical and horizontal signage is carried out on the E-482 road (Av. Juan Montalvo).
- Consider pedestrians, motorcyclists, cyclists, and vehicles in a specific order, without falling into saturation by urban infrastructure; that is, prioritizing horizontal, vertical, and traffic light signaling since it is a determining factor for safety given a general approach.

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