ANALYSIS OF THE VEHICLE-BICYCLES INTERACTION ON TWO-LANE RURAL ROADS USING A DRIVING SIMULATOR BASED ON FIELD DATA

Juan F. Dols
Instituto de Diseño y Fabricación (IDF), Universitat Politècnica de València, Spain
Jaime Molina
Instituto de Diseño y Fabricación (IDF), Universitat Politècnica de València, Spain
Sara Moll
Highway Engineering Research Group (HERG), Universitat Politècnica de València, Spain
Griselda López
(HERG), Universitat Politècnica de València, Spain
F. Javier Camacho-Torregrosa
(HERG), Universitat Politècnica de València, Spain
Alfredo García
(HERG), Universitat Politècnica de València, Spain

ABSTRACT

The presence of cyclists on Spanish two-lane rural roads is common, so they have to interact with motor vehicles. Due to the speed differential and vulnerability of cyclists, overtaking is one of the most dangerous and frequent interactions. Therefore, a minimum distance of 1.5 m must be observed. The overtaking manoeuvre depends on road section and cyclist group distribution. Interaction between cyclists and vehicles has been characterized in the past but overtaking to cyclist groups has barely been studied. This study uses a driving simulator to analyse how the presence of cyclists and their group configuration affect traffic operation and safety on two-lane rural roads. A fixed driving simulator has been adapted to incorporate cyclists, using speed and lateral position obtained from field studies. Based on field data, a physical scenario and different traffic scenarios have been recreated, so volunteers can drive the simulator – emulating a motor vehicle – tracking their speed, lateral position, and other variables. These results can be compared to those observed for checking the validity of this methodology. The driving simulator offers some results which are difficult to obtain through other methodologies, enabling a better analysis of the phenomenon. By sorting different bicycle patterns and including several volunteers, the impact of bicycle pelotons on traffic performance and safety can be characterized. This will help in offering recommendations to integrate cyclists and motor vehicles in a safer way.

1. INTRODUCTION

Nowadays, there is an increasing presence of bicycle traffic on Spanish two-lane rural roads, which must be considered when analysing safety and operation of traffic on these roads. Most of the cyclists who use rural roads are sport cyclists, and they usually ride individually or in groups. Due to the differences between cyclists and motorized vehicles, the severity of the accidents registered on rural roads are higher than on urban environment. In fact, in 2019, the 60% of the fatal accidents with cyclists involved were registered in rural roads, despite most of the accidents with cyclists involved (72%) were registered on urban environment (DGT, 2019).

Due to the speed differential and vulnerability of cyclists, overtaking is one of the most dangerous and frequent interactions. The overtaking manoeuvre has been studied in many research using different methods and analysing different variables. Most of these previous studies were focused on the safety point of view, and they analysed mainly the lateral clearance between the overtaking vehicle and the bicycle and the overtaking vehicle speed. Regarding the method used to develop these studies, most of them used instrumented bicycles to collect real data (Llorca et al., 2017; Dozza et al., 2016; García et al., 2019; López et al., 2020). Other studies used naturalistic data (Debnath et al., 2018) or test track data (Rasch et al., 2020). Another methodology that allows obtaining data of the overtaking manoeuvre to cyclists is the use of driving simulators (Bella and Silvestri, 2017; Bianchi-Piccinini et al., 2018; Farah et al., 2019; Mecheri et al., 2020; Goddard et al., 2020; Rossi et al., 2021).

This methodology allows obtaining data from the drivers' point of view, investing relatively short time and in an easy and economical way. All the previous studies, that analysed the interaction between motorized vehicles and cyclists on rural roads using a driving simulator, considered only one cyclist riding alone, and simulated scenarios designed by varying the geometric characteristics of the rural road, the position of the cyclist or the oncoming vehicle presence.

None of them studied the effect of groups of cyclists riding on rural roads, and real geometric and traffic scenarios considering cycle traffic and oncoming traffic were not simulated.

The presence of cyclists on two-lane rural roads not only affects safety, but also traffic operation. Moll et al. (2021) performed a study using a traffic micro-simulator to analyse the effect of cycle traffic on traffic operation on narrow two-lane rural roads. Their results showed that cycle traffic presence decreases motorized vehicle average travel speed and increases percent followers and delays. The use of a driving simulator allows to obtain several performance measures to characterize and analyse the affection on both safety and traffic operation.

Previous studies performed by Llopis Castelló et al. (2016, 2019) proposed a methodology for road safety analysis using driving simulators. Following this methodology, the virtual scenario is designed, recreated and loaded into the driving simulator based on geometric characteristics of the road and surroundings.

Then, a set of driving simulator tests is performed by some volunteers. Finally, the results of the simulator are validated by comparison with the real data obtained on field observations. At last, the results obtained from the simulator can be analysed to obtain conclusions. This methodology can be used not only to analyse road safety, but also to characterize traffic operation (Dols et al., 2021).

The present study aims to simulate a real geometric scenario and three traffic scenarios obtained from field observations. Other innovation of this study is that the traffic scenarios simulated include groups of sport cyclists, riding in different configurations. Using the developed driving simulator will be possible to obtain some results which are difficult to obtain through other methodologies, enabling a better analysis of the phenomenon.

2. METHOD

The first step was to create the road physical virtual scenario. The physical recreation used the methodology developed by Dols et al. (2016) that requires to define the road geometric characteristics (alignment, elevation and cross-section), as well as the environment (side margins, vertical signs, road markings, surroundings, etc.). From this information, the virtual scenario can be recreated and loaded into the driving simulator. In the next step, a group of volunteers (who must be representative), will travel through the virtual scenario using the simulator. Fig. 1 shows the methodology used.

This paper is focused on the first stage. The main objective was to incorporate groups of cyclists inside the driving simulator scenario, and to simulate the real road and traffic characteristics in a realistic way. The traffic scenarios implemented corresponded to real scenarios observed in the segment.

Therefore, the results of the simulator can be validated with field data in order to analyse the behaviour of the drivers in the simulator with respect to that observed in the field. In addition, on the second stage, data from driving simulator test can be used to evaluate safety and traffic operation in the road.

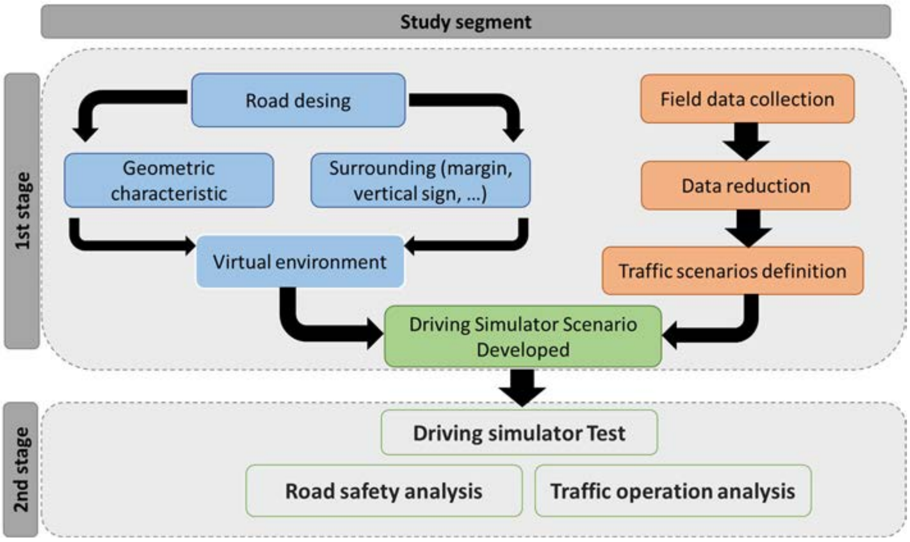


Fig. 1 – Methodology used to develop road segment and cross-section characteristics.

2.1 Study segment description

This study was performed in a segment of two-lane rural road located in the road CV-310, in the region of Valencia (Spain). The study segment is 4,860 meters long, and it has a lane width of 3.2 meters. The road has paved shoulder varying the width between 1.5 and 2 meters. The road has a downward slope of about 7.2% from the beginning to the end of the segment analysed. An important feature of this segment is that the shoulder is coloured in red.

2.2 Field data collection and reduction

Data collection consisted of naturalistic recordings made simultaneously in the extremes of the segment, using small high-definition video cameras. The video cameras were discreetly located so that they could not be noticed by road users. Data reduction beginning with reviewing the videos recorded in the start point of the segment, and the timestamp and the typology of each road user was registered. Finally, the videos recorded at the end point of the segment were reviewed to complete the dataset. This data reduction was realized in both directions of the studied segment. As a result, the time space diagrams considering the trajectories of each road user were obtained and used to select the traffic scenarios with the maximum and the minimum bicycle traffic for the simulations.

2.3 Virtual scenario

The virtual scenario design can be a laborious process. As Dols et al. (2016) indicated, the scenario geometric and traffic characteristics to be modelled will determine the accuracy of the model and therefore the success of the study to be carried out. Modelling the virtual scenario requires a high degree of specialization in many areas (traffic, road design, road safety, among others) as well as graphic simulation techniques and 3D object modelling, to reproduce real-world conditions as good as possible

The present study aims to simulate a real geometric scenario and different traffic scenarios obtained from field observations. To do this, firstly, a physical scenario has to be developed.

The physical scenario has to be similar to the real road segment, so their design is based in real data collected on the road and obtained from computer programs based primarily on satellite imagery. Once the physical scenario has been designed and built, the traffic scenarios have to be designed. The traffic demands considered in each traffic scenario were based on field observations. However, the main challenge is to integrate the groups of cyclists and their observed behaviour in the simulator.

2.3.1 Physical scenario

The physical scenario was designed by the Institute for Design and Manufacturing (IDF) of the Universitat Politècnica de València based on the Multilayer Editing Procedure (Dols et al., 2016, 2021). This methodology implies that the scenario editing procedure of all elements to define the virtual scene are modelled as a multi-layer editing technique in which different data-files are including the types of information needed to model the road and their surrounding virtual scene.

2.3.1.1 Road Design Geometry

The road design was developed using Civil 3D software. Then, the horizontal and vertical alignments, and the cross-section characteristics were provided in an Excel file with the coordinates (x, y, z) of the axis of the road, the edges of the lanes and the platform given at each meter. One of the characteristics of this section is that the width of the shoulder varies between 1.5 m and 2 m, the majority being 1.5 m wide, while the lane width is constant during all the segment To consider the variation in the cross section, the equations of the shoulder width limits were obtained as an input to the physical development of the model for the simulator.

Terrain model of the surrounding area

ASC file with the cartography, downloaded from the website of the National Plan for Aerial Orthophotography (NPAO), and combined with a more precise tachymetry.

Orthophotography of the study area

Also downloaded from the National Plan for Aerial Orthophotography (NPAO) website in Enhanced Compression Wavelet (ECW) format.

Inventory of Elements of the road and the environment

A file in Excel format, with all the elements of the superstructure as vertical signs, road beacons, road markings, lateral safety barriers and lateral walls was completed. Each road and environment element were described and their specific location in the road, referenced to the beginning of the road segment, were registered.

For each observed vertical sign, the location where it appears, referenced to the beginning of the study segment, and the margin where it appears were indicated. In addition, to know the orientation of each of them, the direction of circulation was noted. Fig. 3 show the different vertical signs observed in the study segment, and lately introduced into the virtual physic scenario.

Fig. 2 - Vertical signs observed in the study segment.

In the study segment some road beacons to signalize the curves were observed (Fig. 3). These road beacons were located in the road indications their point location, referenced to the beginning of the segment, and their margin and orientation. The number of signs that formed each beacon (simple or double) was also indicated. The location of them was always out of the road, and of the lateral safety barrier, when it was present. In the study there were also observed a speed radar sign and its corresponding speed radar device (Fig. 3).

(a) (b) (c) (d)

Fig. 3– (a) simple road beacon; (b) double road bacon; (c) speed radar sign; (d) radar box observed in the study segment.

The different types of road markings observed in the study segment are shown in Fig. 5.

The lateral centre lines, which separate the lane and the shoulder, were continuous in all the segment, while the centre line presented the five types shown in Fig. 5. These data were reported considering the points were the lines changed along the segment. In the study segment there are simple and double lateral safety barriers (Fig. 6), most of them are double safety barriers, used to improve the safety for motorcyclists; and there are only two segments with a simple safety barrier.

The locations of the safety barriers were defined indicating the type "Simple" or "Double", and the point of the road and the length where this containment system exists. In addition, it has been differentiated for each of the road margins in an increasing direction of road length, referring to the origin of the study segment. The disposition of the safety barriers will be on the outside of the hard shoulder.

Fig. 4 - Different centre and lateral line types observed in the study segment.

(a) (b)

Fig. 5 - Lateral safety barriers observed in the study segment. (a) simple safety barrier; (b) double safety barrier.

In this section there are several lateral walls whose height, and the initial location and length were provided. The texture and colour of each lateral wall was registered in order to obtain a similar result in the virtual scenario. A CAD file was also generated with the location of environmental elements that cannot be associated with a specific point of the road, such as buildings and vegetation. Two types of trees were defined in the virtual environment, they were orange and pine trees.

2.3.2 Traffic scenarios

As a novelty on driving simulator studies, real traffic scenarios were simulated, considering the same cycle traffic and oncoming traffic than observed on the field. This fact makes the validation process more realistic, so it is possible to validate the simulator results for each traffic scenario simulated in a more exact way. Therefore, the physical appearance of all road users, and their trajectories along the road segment were analysed.

2.3.2.1 Groups of cyclists

The trajectories of the cyclists along the segment depend on the shoulder width at each point. Therefore, the trajectories of the cyclists had to be incorporated in the simulator considering the lane and shoulder width variation. The positions of the bicycles were different considering the direction, as the lane and shoulder widths. The bicycles positions were defined as y_br and y_bl, for the right and left side of the road respectively. Then, for the direction with x positive values, the trajectory of the bicycles, which ride on the right shoulder, was defined by:

While the trajectory of the bicycles in the opposing direction, when they ride in the left shoulder, were defined by:

$$y_{br} = \begin{cases} y_r + \frac{y_{rs} - y_r}{2} & \text{if } y_{rs} - y_r \geq 2.2 \\ y_{rs} - 1.1 & \text{if } 2.2 > y_{rs} - y_r \geq 1 \\ y_r - 0.1 & \text{if } y_{rs} - y_r < 1 \end{cases} \tag{1}$$

$$y_{bl} = \begin{cases} y_l + \frac{y_{ls} - y_l}{2} & \text{if } y_l - y_{ls} \geq 2.2 \\ y_{ls} + 1.1 & \text{if } 2.2 > y_l - y_{ls} \geq 1 \\ y_l + 0.1 & \text{if } y_l - y_{ls} < 1 \end{cases} \tag{2}$$

These trajectories correspond to a single cyclist. When two cyclists ride two-abreast, they are modelled as two bicycles, separated 1 m and centred in the defined positions for one cyclist. To better reproduce the groups of cyclists in the simulator, the different groups were simulated based on a combination of one cyclists and a couple of cyclists riding two-abreast.

The distance considered between cyclists who ride in-line was 1 m. About the speed at which the bicycles ride, there was considered that all the bicycles ride at the same speed, and this speed was considered constant based on the values obtained in filed data.

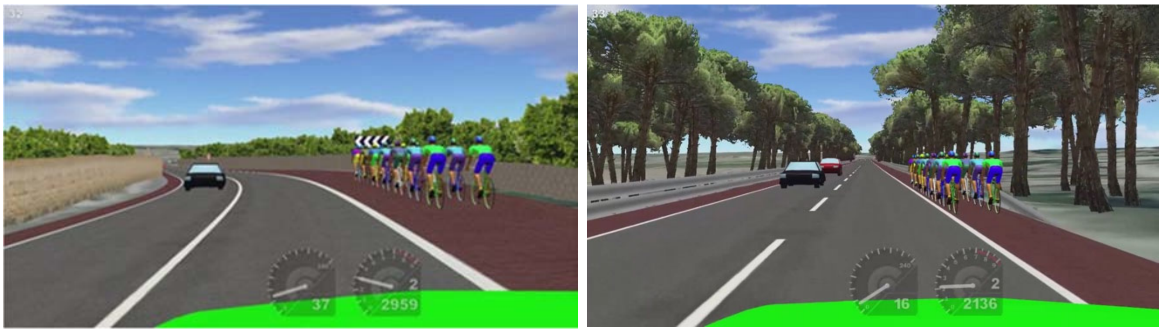
Oncoming motorized vehicles

All the oncoming vehicles were considered to travel at the same constant speed. This speed was obtained from the field data collected in the study segment. Regarding the lateral position, the oncoming motorized vehicles were centred in the lane for both directions, as it was the most common position observed on field.

2.3.2.2 Cyclists and motorized vehicles appearances in the simulator

The vast majority of cyclists who ride on two-lane rural roads are sport cyclist. Therefore, to increase the reality in the simulator experiment, all cyclists introduced in the simulator were equipped by sport cyclist clothes and helmet. To simulate the reality better, different colours and models were considered for the simulation, for both bicycles and motorized vehicles. In that way, the cyclists and the oncoming vehicles that one participant encounters during the test have different appearance selected at random, as it happens in reality. Fig. 7 shows various examples of overtaking manoeuvres of the vehicle driven in a curve or straight lines section of the scene where the traffic of oncoming vehicles appears at the same time.

In the virtual scenario developed, four types of medium-sized vehicles have been reproduced (5-door sedan, 3-door coupe, sports car and van), with dimensions between 3.8 meters to 4.5 meters in length, widths from 1.72 m to 1.91 m and heights from 1.2 m to 1.82 m. The cyclists modelled occupies a length of 1.52 m, width of 0.52 m and height of 1.52 m, where the only difference between the members of the peloton is the clothing colour they wear.



(a) (b)

Fig. 6 – Cyclists and motorized vehicle appearance reproduced in the driving simulator. (a) overtaking manoeuvre of cyclist peloton in a curve; (b) overtaking manoeuvre of cyclist peloton in a tangent segment.

2.3.2.3 Traffic scenarios simulated

Both bicycle and motorized vehicles traffic data were provided for the simulator in an Excel file, which included the direction of the simulation, the Average Travel Speed (ATS) of motorized vehicles and bicycles, and the initial location of each road user when the test starts.

The simulated traffic scenarios were selected from the field dataset. Regarding the time-space diagrams obtained, the vehicle who overtakes a higher number or cyclists had been chosen as the traffic scenario 1. The traffic scenario 2 was selected from the data obtained in the opposing direction, in that way participants changes the direction of travel and so they are less conditioned to the same travel. The traffic scenario 2 was selected considering a vehicle trajectory which encounters a lower cycle traffic. Then, it is possible to compare the effect on the traffic operation considering one scenario with high cyclist demand and another with a lower one. Finally, a third scenario was designed based on the traffic scenario 1 and doubling the cycle traffic. This scenario was not observed on field but can offer results about how a high cyclist demand affect the safety and traffic operation in a rural road. In these scenarios, a similar volume of oncoming vehicles has been considered, in order to compare the condition generated by varying only the cycling volume.

2.4 Driving simulator

The experimental tool used in this study is the SE2RCO driving simulator, designed and developed by the Institute for Design and Manufacturing (IDF) of the Universitat Politècnica de València (Llopis-Castelló et al., 2016). This tool it is based on a fixed-based simulator which provides the capability for implementation different simulation software, data collection and driving assessment in real time. It is composed by simulation computer, threescreen-display monitors with 120 degrees of field of view (FoW) (1.80x0,34 m and Matrox TripleHead2Go graphics card), steering wheel, pedals, and gear-shift lever and adjustable seat based on a Citroen Saxo. It is capable to acquire longitudinal and lateral speed, location and azimuth with a frequency of 10 Hz. It has been instrumented with load cell (brake pedal force), potentiometers to measure displacement in the three pedals, micro-switch to detect gear-lever position, encoder for measuring steering wheel angle and torque sensor for the steering wheel torques.

3. RESULTS AND DISCUSSION

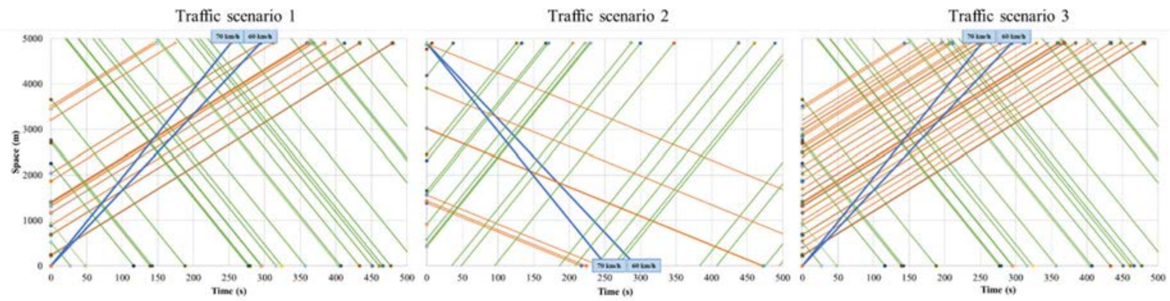
3.1 Field data

The field data collection was carried out on a Saturday morning, since it is when it was expected to see a greater number of groups of cyclists. Table Table 1 shows the main results of the field data collection. According to the results of average travel speeds (ATS) showed in Table 1, the average travel speed of motorized vehicles in both directions for the simulator were considered 70 km/h, while for bicycles a different ATS were stabilized considering the travel direction. Then, for bicycles an ATS of 35 km/h in the direction 1, and of 23 km/h in direction 2 were considered. These average travel speed selected for bicycles in the driving simulator were more realistic than the previous ones considered in other studies which used a driving simulator, since they were obtained from field measurements.

Direction	Initial hour	Duration	Observed bicycles	ATS bicycles (km/h) Mean (SD)	Observed motorized vehicles	ATS motorized vehicles (km/h) Mean (SD)
1	8:20	4:39	287	34.85 (4.72)	777	69.93 (6.78)
2	8:19	4:14	191	22.64 (3.42)	539	68.44 (6.75)

Table 1 – Bicycles and motorized vehicles and their ATS registered during the data collection.

Fig. 7 shows the time-space diagrams for the three traffic scenarios with the trajectories of the bicycles in orange and those of the opposing vehicles in green. The trajectories correspond to straight lines since it was considered that all of them circulated at a constant speed. The trajectories of two hypothetical vehicles that travel the section at constant speed have been represented in blue, one driving at 70 km/h and the other at 60 km/h. It is observed that when a driver travels the section at a higher speed, interactions with more cyclists are produced.



(a) (b) (c)

Fig. 7– Trajectories of bicycles and oncoming vehicles: (a) traffic scenario 1; (b) traffic scenario 2; (c) traffic scenario 3.

3.2 Virtual scenario

According to the scenario design methodology developed by Dols et at. (2021), the total development time of the virtual scenario applied in this study, based on the multi-layer methodology, can be divided into three phases: editing time (obtaining and editing data sources with specific software), programming time (preparation, treatment and adaptation of the data for a specific simulator) and processing time (processing time to generate native files adapted to a specific simulator). Considering that the virtual scenario has been designed for a 4.86 km segment of the road, and according to the hour/km ratios necessary for the implementation of the virtual scenario, the development times results used in each of these three phases have been quantified as follows:

Editing time: 35 hours	Editing time ratio, Rte: 7.2 hours/km
Programming time: 84 hours	Programming time ratio, Rtp: 17.28 hours/km
Processing time: 0.16 hours	Processing time ratio, Rts: 0.034 hours/km

Therefore, the total estimated ratio of development time used in this study is about RT = 24.5 hours/km. This development time can be considered as moderate (between 20 to 35 hours km), compared to other methods of developing scenarios with manual editing, which are usually classified as very high (more than 50 hours / km). The values of the development times of virtual scenarios obtained in this study are consistent with those defined by Dols et al. (2021) in the analysis of virtual scenario development methodologies for the development of road safety audits through the use of driving simulators.

One of the advantages of using this multi-layer scenario design methodology is the fact that it presents the possibility of introducing very rapid changes in the traffic simulation model used. For example, in this work bicycles are moving at a constant speed in each scenario, but if needed, it is possible to modify the behavior model of each independent cyclist, or a peloton as a whole, modifying the specific Excel file with the data required, allowing the analysis to be adapted to more unfavorable or dangerous situations.

In the development of the traffic scenario, the bicycle and vehicle paths have been simulated according to a previously established behavior model. However, the versatility of the method used also allows the introduction of behavior models with variable trajectories for each of the mobile objects on the scene, with only modify the data layer that determines the trajectory of cyclists and vehicles.

One of the limitations of the present study has been the analysis of the physical contacts between vehicles and cyclists. In our work, the modeling of the physics between objects has been carried out without the purpose of studying the effect of the collision between vehicles and cyclists, nor the consequences of the same, since the final objective has been based on determining the behavior of the driver before the appearance of groups of cyclists who have to be overtaken considering oncoming traffic. This current limitation may be the source of future work in which a vehicle-cyclist contact model should be introduced to determine the trajectories and consequences of the collision of cyclists and vehicles circulating on the road. In that case, a contact physics modeling would have to be developed in one of the data layers that allow the generation of the entire virtual scenario.

4. CONCLUSIONS

In this paper the development of a driving simulator integrating cyclists is performed. To recreate the road physical virtual scenario and ensure that it is similar to the real road, naturalistic data was collected by realizing naturalistic observations in the extremes of a two-lane rural road segment. From these recordings, traffic scenarios were obtained, both for motorized vehicles and for bicycles.

Based on field data, both of the road geometry and surroundings and of the traffic, it is possible to recreate the real phenomenon observed on field. Therefore, it is possible to validate the driving simulator results and compared them to field data. Finally, by using the driving simulator it is possible to obtain some results which are difficult to obtain through other methodologies, enabling a better analysis of the phenomenon.

On further research will be possible to analyse the effect of some changes in the safety and traffic operation. These variations can be realized on the geometry of the rural road, as incorporating turnouts, varying the lane or shoulder widths and colours, or varying the speed limit of the road. It is also possible to analyse the effect of variations in the traffic demand.

Future works applying this methodology would allow the analysis of the road safety from both existing roads and others that are in the design phase, by introducing models of traffic behavior of cyclists and vehicles, according to certain cross section configuration or construction, e.g. the introduction of roundabouts, variable widths, slopes, etc.

AKNOWLEDGEMENTS

This study was part of a research project titled “Improvement of safety and operation of two-lane rural roads with cyclists (Bike2Lane)” (TRA 2016-8089-R) subsidized by Spanish Ministry of Science and Innovation. In addition, the authors would like to thank the Road Department of the Valencian Provincial Council, and General Directorate of Traffic of Spain, for their cooperation in field data gathering.

REFERENCES

BELLA, F.; SILVESTRI, M. (2017). Interaction driver-Bicyclist on rural roads: Effects of cross-sections and road geometric elements. Accident Analysis and Prevention, 102, 191-201.

BIANCHI-PICCININI, G. F.; MORETTO, C.; ZHOU, H.; ITOH, M. (2018). Influence of oncoming traffic on drivers’ overtaking of cyclists. Transportation Research Part F: Traffic Psychology and Behaviour, 59, 378-388.

DEBNATH, A. K.; HAWORTH, N.; SCHRAMM, A.; HEESCH, K. C.; SOMORAY, K. (2018). Factors influencing noncompliance with bicycle passing distance laws. Accident Analysis and Prevention, 115, 137-142

DIRECCIÓN GENERAL DE TRÁFICO (DGT) (2019). Las principales cifras de la Siniestralidad Vial España 2019. (ISSN: 2445-0219).

DOLS, J.F.; MOLINA, J.; CAMACHO, F.J.; MARÍN-MORALES, J.; PÉREZ-ZURIAGA, A.M.; GARCÍA, A. (2016). Design and Development of driving simulator scenarios for road validation studies. Transportation Research Procedia, 18: p. 289-296.

DOLS, J.F.; MOLINA, J.; CAMACHO-TORREGROSA, F.J.; LLOPIS-CASTELLÓ, D.; GARCÍA, A. (2021). Development of Driving Simulation Scenarios Based on Building Information Modelling (BIM) for Road Safety Analysis. Sustainability, 13, 2039.

DOZZA, M.; SCHINDLER, R.; BIANCHI-PICCININI, G.; KARLSSON, J. (2016). How do drivers overtake cyclists? Accident Analysis and Prevention, 88, 29–36.

FARAH, H.; BIANCHI-PICCININI, G.; ITOH, M.; DOZZA, M. (2019). Modelling overtaking strategy and lateral distance in car-to-cyclist overtaking on rural roads: A driving simulator experiment. Transportation Research Part F: Traffic Psychology and Behaviour, 63, 226–239.

GARCIA, A.; LLORCA, C.; SERRA-PLANELLES, J. (2019). Influence of peloton configuration on the interaction between sport cyclists and motor vehicles on two-lane rural roads, Journal of Transportation Safety & Security, 12:1, 136-150,

GODDARD, T.; MCDONALD, A. D.; ALAMBEIGI, H.; KIM, A. J.; ANDERSON, B. A. (2020). Unsafe bicyclist overtaking behavior in a simulated driving task: The role of implicit and explicit attitudes. Accident Analysis and Prevention, 144, 105595.

LLOPIS-CASTELLÓ, D.; CAMACHO-TORREGROSA, F.J.; PÉREZ-ZURIAGA, A.M.; GARCÍA, A.; DOLS, J.F. (2016). Validation of Low-Cost Driving Simulator Based on Continuous Speed Profiles. Transportation Research Record, 2602, 104-114.

LLOPIS-CASTELLÓ, D.; CAMACHO-TORREGROSA, F.J.; GARCÍA, A. (2019). Using objective parameters as surrogate measures for Road Safety Audits. In Proceedings of the Road Safety & Simulation International Conference (RSS2019), Iowa City, IA, USA, 14-17 October 2019.

LLORCA, C.; ANGEL-DOMENECH, A.; AGUSTIN-GOMEZ, F.; GARCÍA, A. (2017). Motor vehicles overtaking cyclists on two-lane rural roads: Analysis on speed and lateral clearance. Safety Science, 92, 302-310

LÓPEZ, G.; PÉREZ-ZURIAGA, A.M.; MOLL, S.; GARCÍA, A. (2020). Analysis of Overtaking Manoeuvres to Cycling Groups on Two-Lane Rural Roads using Objective and Subjective Risk. Transportation Research Record, 2674, 148-160.

MECHERI, S.; ROSEY, F.; LOBJOIS, R. (2020). Manipulating constraints on driver-cyclist interactions in a fixed travel space: Effects of road configuration on drivers' overtaking behaviour. Safety Science, 123.

MOLL, S.; LÓPEZ, G. Y GARCÍA, A. (2021). Analysis of the Influence of Sport Cyclists on Narrow Two-Lane Rural Roads Using Instrumented Bicycles and Microsimulation. Sustainability, 13, no. 3: 1235.

RASCH, A.; BODA, C.N.; THALYA, P.; ADERUM, T.; KNAUSS, A.; DOZZA, M. (2020). How do oncoming traffic and cyclist lane position influence cyclist overtaking by drivers?. Accident Analysis and Prevention, 142, 105569.

ROSSI, R.; ORSINI, F.; TAGLIABUE, M.; DI STASI, L.; DE CET, G.; GASTALDI, M. (2021). Evaluating the impact of real-time coaching programs on drivers overtaking cyclists, Transportation Research Part F: Traffic Psychology and Behaviour, 78, 74-90.