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Road and Rail Infrastructure V

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MICROSIMULATION-BASED EVALUATION OF A 30 KM/H ZONE

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Abstract

There is a growing concern about how motorized vehicle flow is affecting the quality of life in Portuguese cities, and many city councils are now promoting sustainable mobility policies. A fundamental instrument to pursue these policies is the hierarchization of the road structure, coupled with traffic calming policies. Evaluating the impacts of traffic calming measures in the road network and in the environment is a difficult and complex work. Using microscopic simulation models for this task is a natural option since they can account both for small effects, such as speed variations along the roads, and large effects, related to traffic assignment. This way, the main objective of this work was to understand the effects of implementing traffic calming measures in a residential area in Viseu, Portugal. The analysis was based on the Aimsun microsimulation software and was focused on delays to drivers, pollutant emissions and safety measures. Part of this work addressed the calibration of the Logit route choice model based on surveys. It was concluded that the traffic calming measures and the 30 km/h speed limit contributes to transfer most of the through traffic and conflicts to the trunk roads that surround the neighbourhood. The intervention causes a slight increase of global delays, emissions and conflicts, but creates conditions to improve the quality of life in the neighbourhood.

Keywords: traffic calming, Aimsun, calibration, route choice, logit models, SSAM

1 Introduction

There is a growing concern about how motorized vehicle flow is affecting the quality of life in Portuguese cities and many city councils are now promoting strategies aiming to reduce the number of journeys by individual transport in favour of public transport or even cycling or walking. One of the main approaches that falls under these strategies is the definition of a correct hierarchy of urban road networks. These strategies involve implementing single or combined measures, which consist of changes applied to the road network, either direct adjustments on the road structure, or in the form of access regulation. Traffic calming strategies, along with these strategies, play a significant role in reducing traffic from crossing the city centre, as well as reducing travel speed. Traffic calming measures aim to create a better urban environment for society at the expense of changing drivers' natural behaviour. As such, the selection and application of these measures must be analysed to identify and quantify the impacts on the different users of the spaces involved, which should be weighted according to the specific characteristics of the site under analysis and the intended results.

The effects of traffic calming measures are traditionally subtle and difficult to quantify. The traditional method, based on before-and-after studies, has some limitations, since it implies

an extended period of observation and analysis during which some factors not considered in the study can vary. As an alternative, microsimulation models have become important instruments for the analysis of transport systems, especially urban road networks, allowing to test, evaluate and compare several alternatives in a controlled environment, before they are implemented in the real world. However, the application of these models is not trivial, and it is necessary to solve a significant set of queries such as the definition of the study area, the data collection and the calibration and validation of the model.

2 Methodology

2.1 Case study

The selected site includes the Quinta do Galo neighbourhood and its surrounding spaces, in the city of Viseu, Portugal. The area is mainly residential, including the Polytechnic Institute of Viseu, two elementary schools, a shopping centre, a healthcare facility, a private hospital and several commercial establishments (Figure 1). Residents complain mostly about high speed through traffic and road safety in some intersections. Several problems were identified, namely: (i) roads with double carriageway in a residential area; (ii) wide lanes and narrow sidewalks with obstacles (trees, poles, etc.); (iii) illegal parking causing visibility problems to pedestrian crossings; (iv) lack of trees and vegetation to break the visual impact of parking along urban roads; and (v) very long roads without sinuosity.

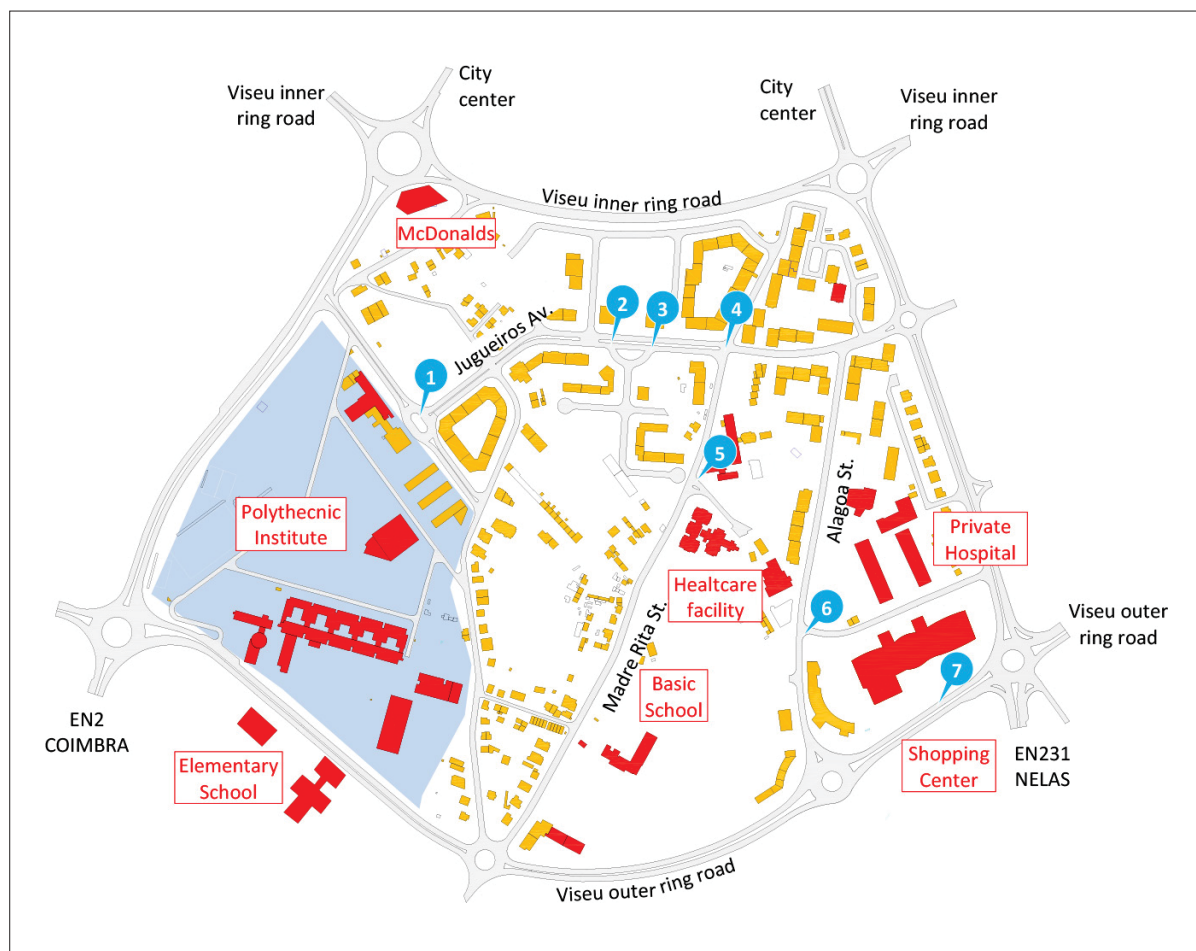


Figure 1 Study area with the position of main traffic generators (the blue markers are referred in section 2.4)

2.2 Basic methodologic approach

The current study presents a possible solution for the selected site where the microsimulation model Aimsun [1] will be used to do a comparative analysis of several traffic calming measures, and to assess the performance of the solution considering travel times, environmental emissions and safety levels.

For the emission analysis it was used the microscopic model embedded in Aimsun from Panis et al. [2]. The main components of air pollution produced by vehicles during combustion are considered in this model, namely carbon dioxide (CO₂), nitrogen oxides (NO_x), particle matter (PM) and volatile organic compounds (VOC).

For the safety assessment approach, the SSAM software developed by the Federal Highway Administration was used [3]. SSAM automates traffic conflict analysis by processing vehicle and pedestrian trajectories (*.trj files). For each interaction, SSAM stores the trajectories of vehicles from the traffic model, records surrogate measures of safety, and determines whether that interaction satisfies the condition to be deemed a conflict.

2.3 Development of the model

2.3.1 Traffic demand

Demand was collected using manual classified counts, for 30-minute periods in the early morning peak, between 7:30 a.m. and 9:30 a.m. and it took place in two consecutive weeks, for a total of 10 days. Data was collected at 18 intersections, including entrances and exits to the site road network through the various roundabouts and to the parking of the Polytechnic Institute, the health centre and the shopping centre.

Finally, the traffic counts were extrapolated to the 60-minute period corresponding to the peak hour (8h00 – 9h00) so that they could be later used to update an existing Origin-Destination matrix (OD) with a new total of 6700 trips/h. Considering the short duration of the simulation, it has been assumed that demand is approximately constant, with little random fluctuations, i.e. default values were used in Aimsun, where the intervals between consecutive vehicles injected into the network follow a negative exponential distribution. Due to the insignificant volume of heavy vehicles, only light passenger vehicles were considered to represent the traffic flow. The legal speed allowed in this area is 50 km/h, while in the Polytechnic Institute the allowed speed is 30 km/h. However, there is a tendency to drive at higher speeds (approximately at 70 km/h) in the surrounding trunk roads.

In addition to the individual vehicle demand, public transport lines were also modelled. The site is served by five routes of public transportation. For each of the routes it was necessary to input the frequency and the path into the simulation. It was also necessary to enter all the information related to stops – lines served, typology and average duration of each passenger entry/exit operation.

2.3.2 Calibration

The main objective of the study was to identify the relative performance of alternative scenarios. In this kind of studies to obtain accurate absolute estimates for the output values is not essential, and so it was decided to use the simulators' default values for most parameters. This way, the calibration effort was focused on the Logit route choice model, given its importance to identify the subtle changes in travel patterns that can be expected after implementing the traffic calming measures. In order to allow a better understanding of the route choice process, instead of the traditional calibration method based on optimization techniques, this task was based on surveys directed to potential drivers.

Under the multinomial logit model used by Aimsun (Eq. 1), the probability of choosing path k amongst all alternative routes of a given OD pair is given by the logistic distribution, where t_k is the expected travel time on path k and θ is a shape or scale factor, to be calibrated.

$$P_k = \frac{1}{1 + \sum_{l \neq k} e^{-\theta(t_l - t_k)}} \quad (1)$$

In order to identify the optimal value for the shape parameter θ , a survey was conducted on the School of Technology of the Polytechnic Institute of Viseu, directed at students, administrative workers and teachers that usually drive a car to work or study. The survey was handed out as printed forms and it was possible to validate 205 of the 209 filled forms. Among other questions aimed to characterize the participants and to understand their knowledge of the Viseu road network, the form included a set of questions directly related to the calibration of θ . Participants were asked to indicate, from 3 alternatives, their preferred path from an origin point to a destination, assuming that the trip would start at 10 AM (off-peak conditions), see Figure 2. The real average travel time was measured using the moving observer method, however the participants had to make their choice based only on their knowledge of the network and personal preferences.



Figure 2 Declared preferences survey: one of the sets of alternative paths the participants were asked to choose from (set 4 of 5)

The results of the survey are indicated on Table 1. There is a clear preference for the faster paths. The fact that considerable proportions of drivers choose the non-fastest path indicates that either they are unable to estimate the differences in travel times and/or that they consider other factors besides the travel time in their decision.

Table 1 Results from the survey and calibration of the route choice model

Set	Origin	Destination	Option	Observation		Model	
				Travel Time (s)	Declared Pref.	θ	Expected Pref.
1	Marzovelos Rbt.	School of Technology	A	203	17,5 %	155,7	17,9 %
			B	170	74,6 %		74,6 %
			C	224	7,8 %		7,4 %
2	Nelas Rbt.	School of Technology	A	207	5,8 %	177,5	4,9 %
			B	186	13,1 %		13,9 %
			C	150	80,9 %		81,1 %
3	School of Technology Rbt.	Santa Cristina	A	177	24,8 %	152,9	23,0 %
			B	152	64,8 %		64,9 %
			C	192	10,2 %		12,0 %
4	Nelas Rbt.	Bus Station	A	263	24,3 %	114,5	17,0 %
			B	253	16,1 %		23,9 %
			C	224	59,5 %		59,01 %
5	Nelas Rbt.	Europa Av.	A	230	36,5 %	69,5	31,2 %
			B	217	39,5 %		40,6 %
			C	236	23,9 %		28,0 %

For each set of paths, the optimal θ value was found as the one that provided the minimum difference between the declared and predicted preferences, resulting in values between 70 and 180. The value $\theta = 100$ was adopted for the Aimsun model.

2.4 Proposal of intervention

Following the analysis of the problems observed and the definition of the objectives, a set of traffic calming measures was chosen that result from the weighting of the effects intended for the site, the foreseeable impacts, as well as the conditions for urban and functional integration (see Fig. 1), namely: (i) changing the inner area to a 30 km/h zone; (ii) eliminating on-street parking in front of the shopping centre (marker M7) to allow a 70 km/h maximum speed; (iii) reducing the number of lanes in the Jagueiros Av. (between M1 and M4); (iv) implementation of raised pedestrian crossings (M2 and M3); (iv) implementation of raised intersections (M5 and M6); and (v) converting a priority intersection to a roundabout (M4).

Speed limitation from the 30 km/h zone alone aims to divert the through traffic to the trunk roads, as well as reducing potential accidents and conflict generation, thus increasing the actual safety of vulnerable users. The roundabout should have only one lane, resulting in higher levels of safety than solutions with multiple lanes [4]. The central island has a radius of 7 m, surrounded by a lane designed for the movement of heavy vehicles, while the inscribed circle diameter is 28 m, and the circulatory carriageway is 7.5 m wide. This geometry guarantees the deflection of the movement of light vehicles and the respective reduction of speed, while ensuring manoeuvrability conditions for heavy vehicles.

3 Results

3.1 Delays

Total travel time increases by 2 %, total driving distance accumulates 1 % and total fuel consumption increases by 3 %, which means that the proposed changes do not cause significant differences (Table 2). The average harmonic speed decreased by 1 %, which would have been expected since the speed was changed in some parts from 50 km/h to 30 km/h.

Table 2 Overall performance values

Parameter	Current	Proposed	Variation
Total travel time [h]	193.25	196.47	2 %
Total driving distance [km]	8006.35	8065.86	1 %
Average harmonic speed [km/h]	40.36	39.79	-1 %
Total fuel consumption [l]	1243.59	1277.99	3 %

To identify the users that benefit with the proposed changes, a series of “variation” matrices (current minus proposed matrices) were obtained through the matrices of average global and individual times per vehicle for each of the OD pairs. It was concluded that the implementation of traffic calming solutions results in an increase of travel times in the interior roads, which makes them less attractive and results in a reduction of the through traffic.

It was also verified that the implementation of these traffic calming measures does not cause drastic changes in the global traffic volumes corresponding to the entire area of influence of the intervened zone (Figure 3). It is expected that the implementation of this type of solutions do not result in a penalty for the community in general, provided that the trunk roads offer spare capacity. This shows that it is possible to delimit zones subject to traffic calming measures without causing considerable disturbance in mobility and local accessibility.

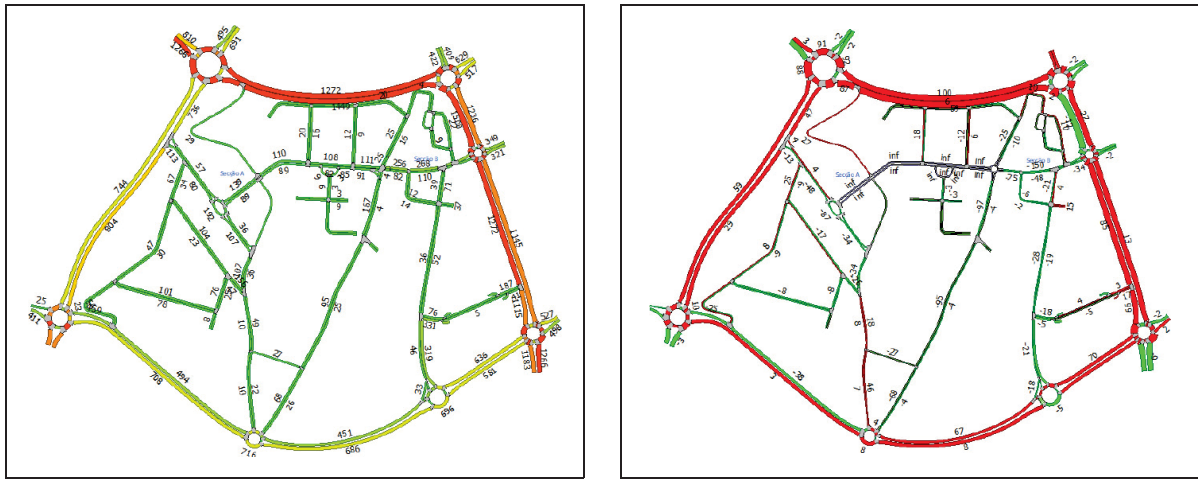


Figure 3 Left panel: traffic flows for the existing network; Right panel: difference of the traffic flows after the intervention (red: increase, green: decrease)

3.2 Emissions

The global atmospheric emissions produced by the vehicles are summarized in Table 3. It can be verified that, after the traffic calming solutions are implemented, the values increase by 2-3 %. However, the results also show that the emissions are, as expected, shifted from the local to the trunk roads. For example, in the “before” case, 6.72 % of the NO_x emissions are originated in the local road. After the intervention, that proportion drops to 2.53 %.

Table 3 Overall emission values considered by Aimsun model

Parameter	Current	Proposed	Variation
CO ₂ [g]	2474115	2512858	2 %
NO _x [g]	7619	7760	2 %
PM [g]	1533	1575	3 %
VOC [g]	3740	3811	2 %

3.3 Safety

The SSAM analysis shows that there is a slight increase (2666 → 2984) increase in the rear-end conflicts due to the increase the queues upstream of the roundabouts in the trunk roads. On the other hand, the most serious conflicts associated with crossings (11 → 8) and lane-changing (299 → 277) are reduced.

4 Conclusions

This study explored the effects of implementing traffic calming measures and a 30 km/h speed limit in a residential area that currently deals with excessive traffic and road safety problems. A microscopic traffic model was integrated in conjunction with safety and emissions models to assess the consequences on traffic performance, safety and emissions generated from vehicles. The calibration of the route choice model was based on a declared preferences survey. The answers revealed a significant dispersion of choices, proving that drivers can’t accurately estimate their own travel time and/or consider other variables when making their route choice. The results also allowed to calibrate the parameter θ of the Logit model used

by the microscopic simulator, concluding that, for the routes analysed, this values varied between 70 and 180. Comparing the before and after models, and looking at the delays and traffic volumes, there was a global increase of the delays in the inner streets, which would be expected since the study area went from 50 km/h to 30 km/h. However, this increase makes the inner zone less attractive for motorized journeys and consequently results in a decrease in through traffic. The proposed solution contributes to a small increase in emissions compared to the current situation. These are mainly concentrated in the trunk routes, having a reduced value in the residential area that is further decreased in the “after” scenario, thus contributing to an improvement in the quality of life of residents and visitors of the neighbourhood.

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