How to deal with noise map calculation models in Brazil

Haryadne Carniel, Talita Pozzer, Marcos Holtz, Davi Akkerman
Harmonia Acústica, Brazil.

Summary

Due to the entry into force in 2016 of the law that establishes the elaboration of a noise map for the city of São Paulo-Brazil, the necessity of research in this area has increased because the shortcoming information on how to develop it in Brazil. In this context, a crucial factor is that there are not environmental noise calculation standards for the Brazilian cities characteristics. This paper presents a study comparing simulations by European methods of calculation with field measurements from a São Paulo's neighborhood. The main objective is to investigate the difficulties and propose solutions when considering all the inputs that might be taken into account when elaborating the first noise map of such unique city.

PACS no. 43.50.Rq, 43.28.Js

1. Introduction [1]

Noise and its effects on people's health and well-being is a problem that has been increasing. This concern is even more evident in large centers such as the city of São Paulo. Evidence of the harm caused by noise and the search for acoustic comfort led to the creation of Law 16.499 in 2016, which established the obligation to implement a noise map in the city of São Paulo [1].

The creation of this law unveiled technical challenges of drawing up the map. The main difficulty in elaborating a noise map in Brazil is that there are no specific sound propagation models of environmental noise to the reality of Brazilian traffic. For São Paulo it is even more complex due to the wide variety of vehicles types and pavements. Another problem concerns about the lack of the knowledge and characterization of pavements properties. The predictive models available in commercial software are based on the European fleet. This fact represents a huge problem due to the fact that Brazilian's fleet is composed of old vehicles, which are not so common in European cities. Only two cities in Brazil have developed noise mapping: the city of Fortaleza, that adopts the European recommendation [2] [3], and city of Belém, that uses a Chilean study as reference [2], [3].

In South America, Chile is an example of country with an advanced culture of noise mapping. Started in 2005, the process compared European models with values measured in the field, to find which of these models was more similar to the Chilean reality; the second step of this study proposed a specific methodology for the calculation[4].

Following Chilean study, this paper presents a study about the European models applied in Brazilian context, as well as the evaluation of other factors that can influence the elaboration of the map, such as the use of traffic lights, the use of the maximum or average velocity for characterization and the height of the microphone to take the measurements.

1.1. Objectives

The objective of this work is to propose a method that can be incorporated to elaborate the noise map of São Paulo, based on a study carried out in a region of the city.

1

2. Methodology

The study was conducted in a selected region of the city that comprises a significant range of road traffics characteristics. Hence, it was chosen a region involving roads with light and heavy vehicles, different speeds and pavements, and the variation of quantity of vehicles, covering low, medium and high flow routes.
It was taken 20 points of measurements spread across the chosen region, as shown in Figure 1. The microphones were positioned at 1.50 m height. This height is commonly used in Brazil due to the requirement of the national standard ABNT NBR 10151[6]. However, it is recommended the measurements to be made at 4 m height to avoid the reflections. For this reason, simultaneous measurements were also made in 4 points at 4 m in height, in order to evaluate if there is any difference according to the procedure.

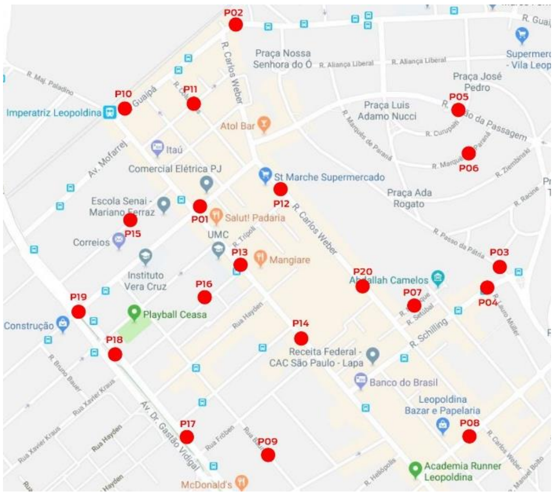


Figure 1: Measurement points localization

A difficulty experienced in the elaboration of the noise map of this region is that there is no up-to-date vehicle flow database to overcome this fact. Videos were recorded during the measurement to assist with counting vehicles.
Another challenge faced was the poor knowledge about the road pavements. Thus, the visual inspection methodology recommended in the European good practice guide [2] was used. The pavements were divided in 4 basic types based on the EU recommendation and the little existing knowledge about the Brazilian pavements. The 4 types are: uneven pavement stones, even pavement stones, cement concrete and smooth asphalt. The pavements were classified according to the relationship available at CNOSSOS[7] as shown on Table 1.

The calculation methods used were RLS90, CNOSSOS, NMPB96 and NMPB08 [8], [9]. In addition, the measurements were compared between 1,5 m and 4 m height, the adoption of average or maximum speed and the adoption of traffic lights was also investigated in the simulation.
To identify the average speed, the methodology of the EU recommendation was used. The average speed was estimated using a vehicle and by driving alongside the other cars, checking the speed at various points on the track.

3. Results and Discussion

The model comparison will be presented first, so that the next analyzes are already based on the specific model.
In order to verify the best model, the sound pressure levels obtained by simulation at each point were

Table 1: Pavements and their correlation on each model

EUROPEAN GOOD PRACTICE GUIDE	*CNOSSOS*	*RLS90*	*NMPB 96*	*NMPB08*
Uneven pavement stones	CNS_10 - Worked surface	4 - Other paviments	105 - EC: Rough texture Paving	3 - Revêtement R3
Even pavement stones	CNS_12 - Hard elements not in herring-bone	3 - Pavement with a smooth surface	104 - EC: Smooth texture Paving	2- Revêtement R2
Cement concrete / Rough asphalt	CNS_07 - Brushed down concrete	2 - Concrete or corrugated mastic asphalt	103 - EC: Cement concrete	2- Revêtement R2
Smoth asphalt	CNS_01 - Reference road surface	1 - Smooth mastic asphalt, asphalt concrete or blinded mastic asphalt	1 - Enrobé bitumé	1 - Revêtement R1

plotted. These values were compared to the measured values in the same plot. Thereby, it is possible to determine which simulated values were closer to the measured situation. This comparison was made with and without crossing, for average and maximum speed.

It turned out that CNOSSOS method had the best results, representing more than 48,75% of the satisfactory results for the all cases. NMPB 08 has also proved to be a satisfactory method, while RLS 90 and NMPB 96 were very distance of our reality. The Figure 2 presents an example of the methods comparison for average speed and considering the crossing, that is the most common use.

It is possible to observe in the Figure 2 that the point “P6” represents a problem, due to the fact that the sound pressure level on this position is so far from the sound power level calculated with any method. This is possible to happen by virtue of the difficulty to obtain the acoustics characteristics of this road, which has a low traffic flow. Its measurement was susceptible to many residual sources such as dogs bark, helicopter and people talking near the microphone. Therefore, the poor characterization of this road can be the reason that this point was so different than the others.

As expected, CNOSSOS method presented better results using the average speed parameter than using the maximum speed one, since it considers the speed input as the average speed for the calculations. However, the largest difference when using the maximum speed was 1,4 dB which has a little representativeness. Thereby it is possible to conclude that CNOSSOS works better if it is possible to use the average speed, although it can also be a good method when only the maximum speed is available. The Figure 3 shows these evaluations.

In a further investigation, it was observed that the consideration of the crossing on the calculation settings leads to an increase on the sound power level, while the simulation without the crossing was closer the real situation. This case is show in Figure 4.

The measurements at 4 m height were taken just for 3 points, where it was possible to observe that the sound pressure level was equal or very close to the sound pressure level measured at 1,5 m height.

Moreover, it was possible to evaluate that the use of some methods like NMPB96 does not affect the sound pressure levels when the crossings were considered on the simulation, fact that shows another shortcoming of the model.

Other important result concerns the RLS90 method, which has proved not to be a suitable method to be used in Brazil. It is of paramount importance once most companies use this methodology without simulation, just using the measurement for calibrating the sound characteristics of the roads. This indicates that Brazil needs more studies to discover if the sound propagation calculations of RLS90 without simulation agrees with the real situations.

Considering all the facts aforementioned, it is possible to conclude that CNOSSOS, adopting average speed of the road, without the crossing, has better inputs to do a noise map of São Paulo. Some of these inputs can be easily defined by the European recommendation, such as the distribution of the vehicles for day, evening and night conditions, meteorology and ground curves. Other inputs were taken automatically when importing the roads using OpenStreetMap, and some others were calculated in the CadnaA, such as the direction of the traffic flow and the gradient of the roads.

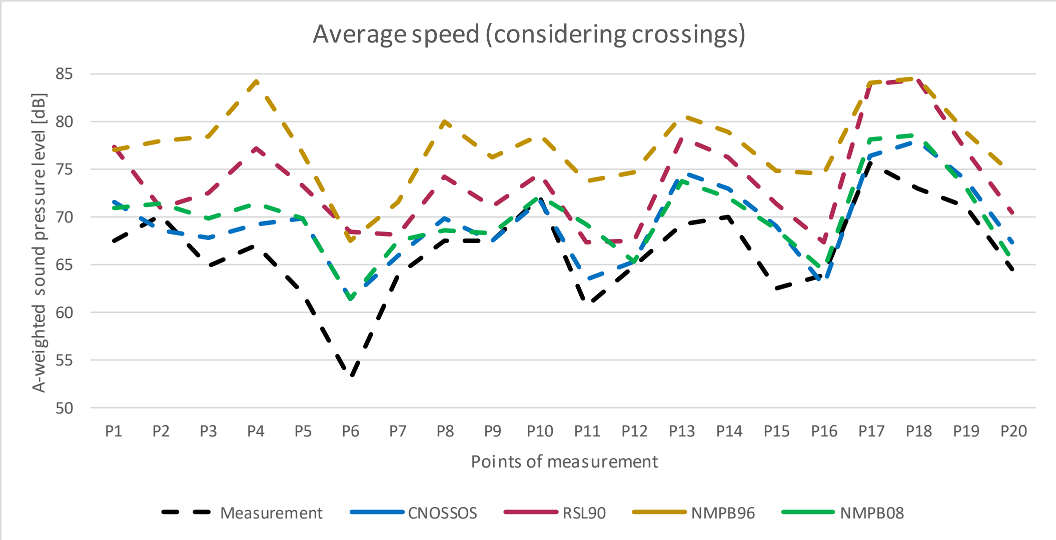


Figure 2: Models comparison for average speed considering the crossings.

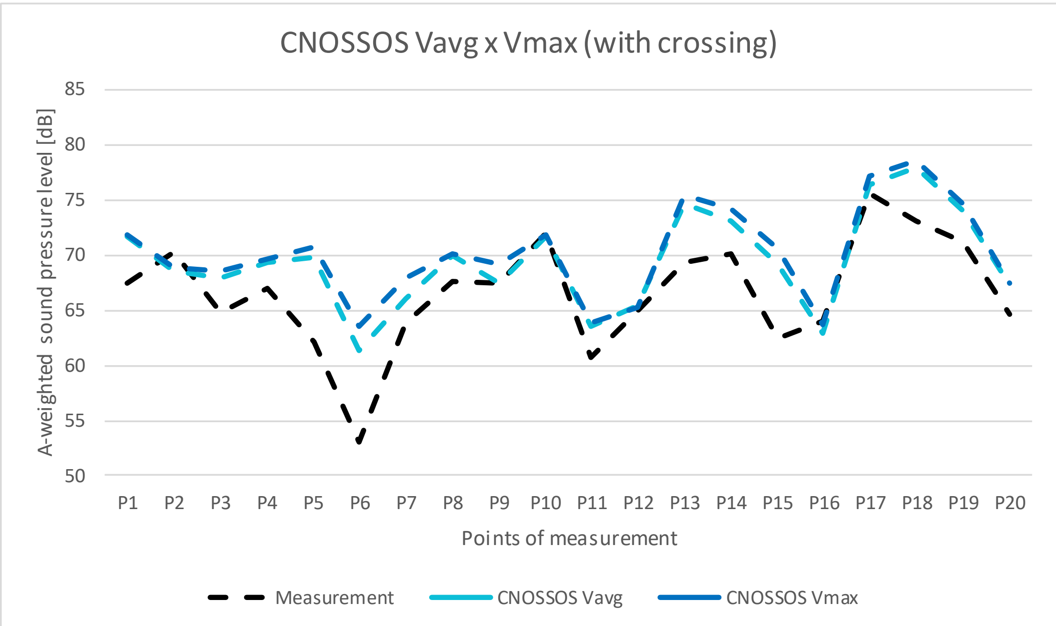
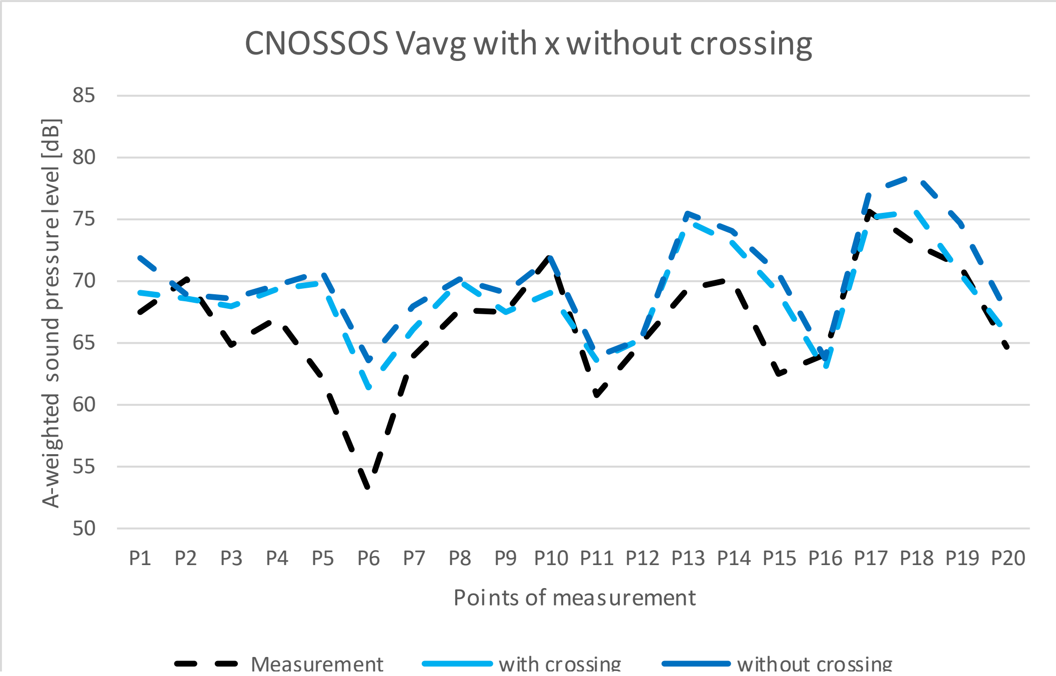


Figure 3: Velocity comparison for CNOSSOS model and with crossings.



4. Conclusions

Based on the study, it is possible to conclude that CNOSSOS is the best method to use in São Paulo to a noise map of the city. In this paper, it was discussed about the inputs of this method and it has been found that the use of the average speed without crossing is the best scenario.

One of the main difficulties of this study was to characterize the pavements, due to the lack of information available about them in Brazil. In order to overcome this, the selection of the types of pavement was made with a visual inspection. This method inserts deviations that affects the accuracy of results.

In addition, as future works, it is suggested further researches about the sound propagation calculation of RLS90 method

Another important study is concerning the construction of acoustics zone map of the city to use the noise map together for making a sound urban plan.

Moreover, this paper can be improved by adding more measurements, specific analysis of the low traffic flow roads and how to characterize roads with different kind of pavements such as way for cars and different way for buses.

References

[1] Lei no 16499 de 20 de julho de 2016, "Dispõe sobre a elaboração do Mapa do Ruído Urbano da Cidade de São Paulo e dá outras providências"

[2] WG-AEN, "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure", 2007.

[3] F. Aurelio Chavez Brito, "The Fortaleza noise mapping project: A tool for the definition of noise action plans for the airport, the light rail system, and the Ceara musical event.," J. Acoust. Soc. Am., 2010.

[4] J. Sommerhoff, M. Recuero, and E. Suárez, "Community noise survey of the city of Valdivia, Chile," Appl. Acoust., 2004.

[5] E. Moraes and N. Lara, "Mapa acústico de belém", 2004.

[6] ABNT "NBR 10151: Avaliação do ruído em área habitadas, visando o conforto da comunidade - Procedimento", 2000.

[7] "Appendix 10 : Guide for Mapping Existing National Road Methods to the CNOSSOS-EU Road Source Method,".

[8] S. Kephalopoulos, M. Paviotti, and F. Anfosso-Lédée, Common Noise Assessment Methods in Europe (CNOSSOS-EU). 2012.

[9] CadnaA, "Reference Manual".