inter-noise 2008 From Silence to Harmony
37th International Congress and Exposition on Noise Control Engineering
26-29 October 2008·Shanghai·China

Assessment of the Impacts in the Traffic Noise in Urban Centers by Changing Modal Split: Simulation with Macroscopic Models

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ABSTRACT

It is known that buses engine noise is relatively higher when compared to light vehicles engines. It is also well known, by transportation and urban planners, that the number of private cars running in urban areas is significantly higher than trucks and buses. Thus, the contribution to noise levels on urban areas (streets and avenues) due to the traffic volume of private cars operation is generally higher. In this context, one of the possible strategies to urban planners and transportation engineers, regarding noise reduction in urban areas, is the management of the passengers transport modal split. Those strategies have the potential to reduce the total number of vehicles in operation and consequently, reduce environmental impacts such as traffic noise. The main objective of this paper is to evaluate, based on the use of available noise prediction macroscopic models, the relationship of managing modal split in urban areas and traffic noise. In addition, a sensitivity analysis to assess different modal split alternatives is conducted in two specific cases: (I) assuming a modal split where 50% of the buses in operation is formed by electric vehicles and (II) assuming that 100% of buses running are electric. The results show that while individually, buses are a more powerful noise source compared to private cars, modal split where public transport is privileged can produce better results, contributing positively to noise levels reduction in urban areas.

1 INTRODUCTION

Despite the creation of the car having brought advantages as regards the total use of urban space, also brought a series of troubles for cities, such as congestions, traffic accidents, noise and atmospheric pollution, dehumanization because of large areas for to the roads and parks, low economic efficiency because of the need for large investments in the road system and the spreading of cities, among others.

In addition the population growth it has been smallest then the increase of vehicles, especially cars. In 1950, the world population revolved around 2.6 billion inhabitants while the number of vehicles was around of 50 million cars. In 1988 the world population rose to nearly 5.5 billion inhabitants, with a fleet of 500 million vehicles (SILVA, 1998). That is, while the world population has almost doubled, the number of vehicles has been increased ten times.

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This excessive number of private vehicles and public transport, generates constant and intense flows on the streets of cities. According to the Cityhall of Belo Horizonte (1992), this causes traffic congestion besides, two major drawbacks are that the discharge of pollutants into the atmosphere in form of, mainly, carbon monoxide (CO) and carbon dioxide (CO2), and noise that is closely related to the vehicles types and flow characteristics through the city.

The vehicular traffic is the main source of noise in urban centers. Studies on the vehicles sound levels has showed that each car is a sound source of about 70-75 dB at a distance of 7 meters, while a bus of public transport is around of 85-90 dB (A) (PIMENTEL-SOUZA, 2000).

In this context, surveys show that the sound power of a heavy vehicle (buses and trucks) is 9.12 times greater than the power of a small vehicle (CAN et al., 2002). Consequently, a preliminary and superficial assessment may take a wrong conclusion that heavy vehicles are the principal responsible for the urban traffic noise.

This premise is not true according to the transportation modal split in urban centers. Overall, it can be said that, in major Brazilian cities, about 80% of vehicles are private cars and around 10% are heavy vehicles (the remainder are other types of vehicles, motorcycles, etc.). So, despite the heavy vehicles noise be bigger, the percentage of this kind of vehicle is significantly smaller and, therefore, not responsible for the largest share of noise in urban traffic.

Moreover, it can still be calculated a relationship between noise per vehicle per person, where it appears that the share of public transport buses is minimal. Whereas a small vehicle emits around 70 dB (A) and carries on average about 1.5 passengers in the major urban centers and that a bus emits about 85 dB (A) carrying about 100 passengers, would lead to an emission per person in the car of 47 dB (A), while the emission per person on the bus is less than 1 dB (A). Obviously, the comparison should be considered only in a purely qualitative evaluation, and that the values are only for evaluation of magnitude order.

However, it can be concluded that, despite a bus produce more noise, it carries a far greater number of passengers and when this is taken into account, it appears that the share of noise per person is significantly lower.

Considering the proportion of number of passengers by vehicles previously presented, it appears that each bus carries on average the same number of passengers that 70 cars, according to the average occupancy rate recorded serve in urban centers.

The basis of these considerations is the motivation for this work. However, since a bus is 9.12 times noisier than a small car and carries the equivalent to the volume of 70 cars, it is possible, changing the division modal, modify the noise levels in urban centers.

Therefore, the objective of this work is to simulate, through changes in the transportation modal split of passenger in urban centers, the implications on the traffic noise. For this, it will be used some statistical macroscopic models to predict traffic noise, as will be explained in the item of methodology.

2 METHODOLOGY

To check the influence of the transportation modal split on the urban traffic noise will be used five macroscopic models, as listed below:

1. (SILVA, 1998)

$$Leq = 62{,}044 + 1{,}779.LogVL + 8{,}282.LogVP \quad (1)$$

2. (DEPARTMENT OF TRANSPORT, 1988)

$$L10 = (10Log.Q) + 33Log(V + 40 + (500/V)) + 10.Log(1 + (5.((Qp/Q))/V) - 26{,}6 \quad (2)$$

3. (CALIXTO et al., 2003)

$$Leq = 7{,}7.LogQ.(1 + 0{,}095.(100.Vp/Q) + 43 \quad (3)$$

$$L90 = 10{,}2.LogQ.(1 + 0{,}095 * (100 * Vp/Q) + 27{,}1 \quad (4)$$

4. (GALLOWAY et al. Apud STEELE, 2001)

$$L50 = 20 + 10.Log(\mathrm{Q} * (\mathrm{V}/1{,}3))/\mathrm{d}) + 0{,}4 * (100 * Vp/\mathrm{Q}) \quad (5)$$

The independent variables of the models are: small and heavy vehicles, average speed and distance between source and receptor.

All models used in this type of work are macroscopic. According with Can et al. (2007), macroscopic models are those that have as independent variables parameters of flow in general, such as traffic volume, vehicles classification, speed and distance between the source and recipient. This type of model is more common because it is easier to calibrate and use. Microscopic models are based on parameters of the vehicles individually, and therefore are more complex.

The basic premise that guides the methodology of this study is to change the modal split, for the transport of passengers (car and bus), in order to transport the same amount of people and, verify what is the influence in the traffic noise. Once that this is a simulation, some considerations needed to be done, as shown below:

- It was there only two types of vehicles in use, cars and buses;
- The average occupancy vehicle (car) used was 1.4 passengers per car;
- The average occupancy of buses used was 100 passengers per vehicle;
- The average speed of traffic considered was 50 km / h;
- The distance between the source and recipient was 4m;
- The initial total of vehicles (buses + car) was 3000;
- The division was modal initial 90% to 10% of cars and buses;
- Considering the occupation of private cars and buses it was considered that each bus is capable of carry on the same number of people that 71 cars;
- The total number of passengers carried was equal to 33,780;
- The modal split was modified until the bus reached 70% of vehicles in circulation;
- It was considered that the noise of an electric bus is equal to a car, about 70 dB.

2.1 Evaluated Parameters

The parameters of noise evaluated in this study were:

• Equivalent Sound Level (Leq): is the parameter that considers the whole range of sound pressure within the measurement determining, through integration, the noise level resulting;

• Levels percentiles (Ln); are the parameters that are, statistically, the thresholds above which the levels of noise were present certain percentage of the time of measurement. Will be quantified the L90, L50 and L10.

2.1.1 Hypotheses Tested

It was evaluated three different scenarios. The first hypothesis only varied with the division modal insertion of withdrawal of buses and cars of movement, keeping constant the total of passengers carried on. The change was made so gradually starting up with 10% of buses and ending with 70% stake thus.

The second case found that half the fleet of buses would be electric vehicles which have emission of noise about 20 dB lesser, similar to a private car. Similar to the hypothesis 1, also varied by the amount of buses between 10% and 70%.

The latter considered that the entire fleet of public transport would be electric vehicles. The variation of the modal split was also made in a similar manner to the other two cases.

3 PRESENTATION AND DISCUSSION OF RESULTS

3.1 Assumptions 1

As can be seen in Figure 1, four of the five models showed a reduction in noise levels for the change of the modal split. The smallest reduction of noise was 1.6 dB in the model of Leq (CALIXTO et al., 2003) and the largest reduction was 2.1 dB in the model of L90 Calixto (CALIXTO et al., 2003).

For the model of Silva et al. (1998) it has been made the adjustment in traffic flow, held to reconcile the fact that the model to consider the traffic in ten minutes may be one of the factors that contributed to the estimate made by this model so that an imprecise.

Generally speaking, it can be said that the reduction of noise verified by the models was low, given the significant changes made in the modal division.

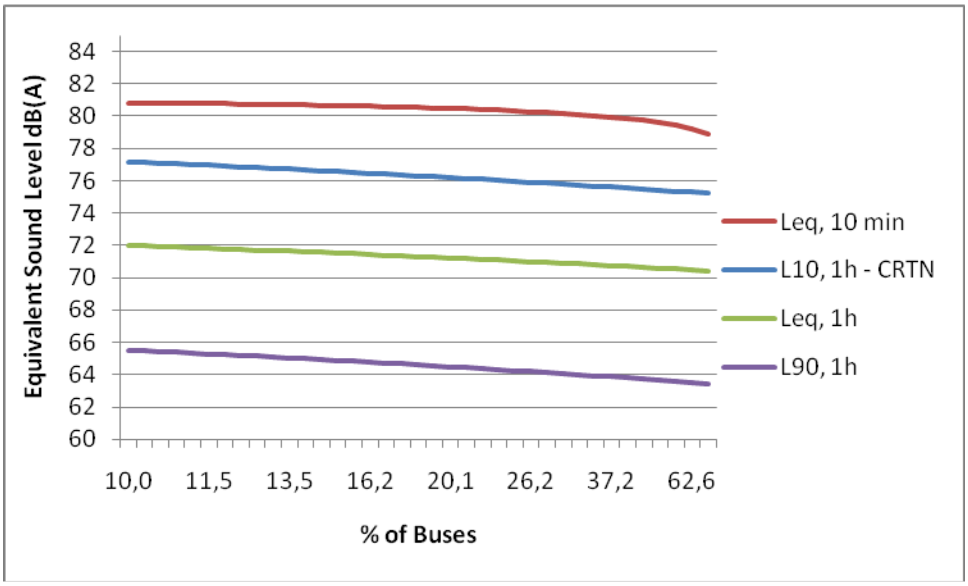

Figure 1: Traffic Noise reduction: assumptions 1

3.2 Assumptions 2

Similarly to the hypothesis 1, four models tended to fall. The largest decrease was seen in the model CRTN (Department of Transport, 1988), equal to 3.2 dB. The smaller reduction, equal to 1.3 dB occurred in the model of Silva et al. (1998). The reduction of noise levels, perceived by the models, was somewhat greater than that seen in the event 1.

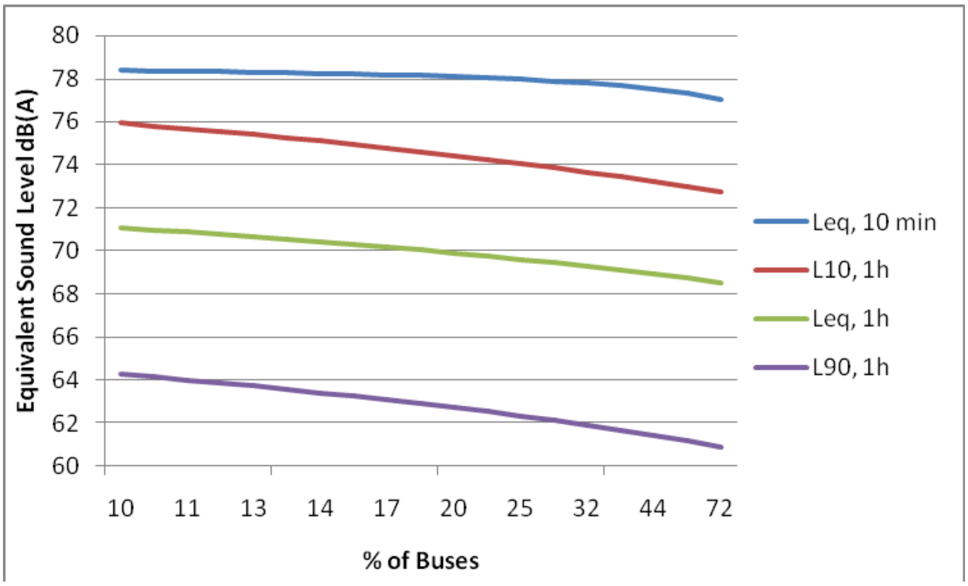

Figure 2: Traffic Noise reduction: assumptions 2

3.3 Assumptions 3

The Scenario 3 showed better results, as expected. Five models showed reductions in the noise levels, with the largest reduction was observed for the model of Calixto et al. (2003) for the L90, equal to 8.3 dB and the lowest reduction was recorded for the model of Silva (1998), equal to 1.4 dB. The average reduction between the models was 6.4 dB. Excluding the model of Silva (1998) this value rises to 7.7 dB.

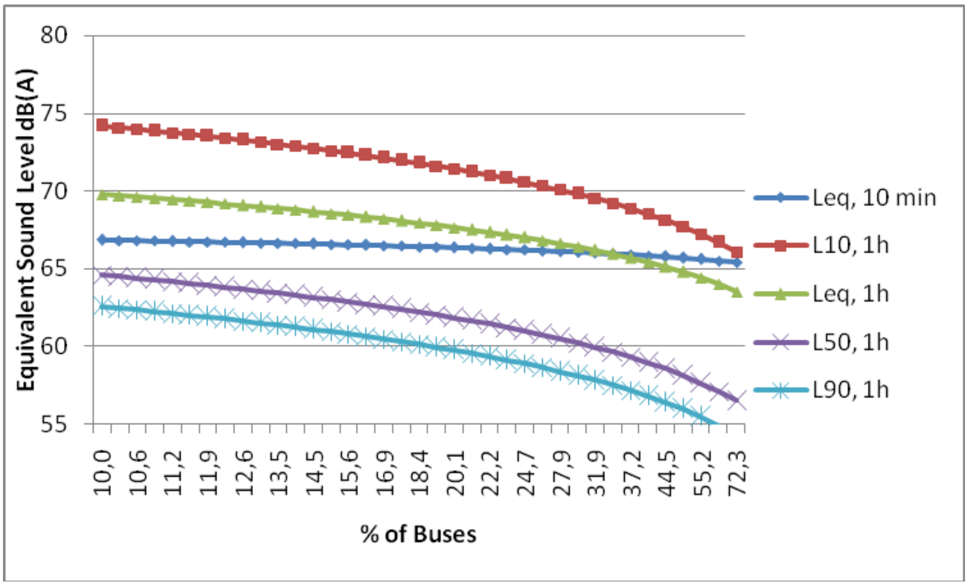

Figure 3: Traffic Noise reduction: assumptions 3

3.4 Comparison between Same Values of Division Modal Varying the Type of Vehicle Fleet

Finally the assessments of this theoretical work was a last procedure, whereas the modal split does not change, which would be the gains of using 50% of the fleet with electric vehicles. Finally, did the same consideration whereas 100% electric vehicle fleet use.

Below are listed the main results of simulations:

50% of the fleet with electric vehicles:

• The use of half the fleet with electric vehicles allows a reduction of about 2 dB;

• The model that showed the largest reduction was of Silva (1998) with 2.4 dB;

• The model with smaller reduction was of Calixto et al. (2003) for Leq, 1h, equal to 1.3 dB;

100% of the fleet with electric vehicles:

• With use of the whole fleet with electric vehicles comes to an average reduction about 7 dB;

• The model that showed the greatest decline was of Silva (1998), equal to 14 dB;

• The model that showed the smallest reduction was of Calixto et al. (2003) for Leq, 1h, equal to 3.8 dB;

4 CONCLUSIONS AND RECOMMENDATIONS FOR OTHERS WORKS

From what was shown in this study it appears that, generally, it is possible to carry the same number of people in an urban centre issuing fewer traffic noise by changing the modal split. It was also possible to conclude that the use of electric vehicles in the fleet leads to even greater reductions.

However, it is emphasized that only were used in this work, macroscopic models for predicting, which have little sensitivity to significant changes in the traffic flow (CAN et al. 2007). In addition, a number of independent variables that could influence the levels of noise are not considered in the model used, such as formation of queues, degree of saturation among others. Therefore, it is believed that reductions in noise levels, in practice, may be even greater than demonstrated by the models.

Thus, it appears this research must be continued and improved to find ways to minimize one of the main diseases in major cities in the world today, using techniques of transport planning and management of mobility.

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