Tenth International Congress
on Sound and Vibration
7-10 July 2003 • Stockholm, Sweden

EXPEDITE METHODOLOGY FOR ASSESSING NOISE LEVELS IN AN URBAN SCENARIO BASED ON A NEW PARAMETER: THE SIGNIFICANT MEASUREMENT STARTS (SMS)

António P.O. Carvalho, Tiago M.D. Ferreira, Rui Calejo Rodrigues
University of Porto, Faculty of Engineering, Laboratory of Acoustics
R. Dr. Roberto Frias, P-4200-465 Porto, Portugal
carvalho@fe.up.pt, tmferreira@mail.pt, calejo@fe.up.pt

Abstract

With the new Portuguese Noise Code (and the new European Directive) there is a necessity to develop an expedite methodology to evaluate noise levels at typical urban scenarios, checking for their ability to be reproduced with reliability at urban spaces with similar occupational pattern. In this work, a new urban scenario was studied representing a typical backyard situation in an urban centre, based on continuous measurements of the Short-term L_{Aeq} performed during one month. The major goals in this work were: to identify, during each day, the preferred time intervals at which any measurement started during it would achieve, with a pre-determined probability, a significant estimation for the all period L_{Aeq} parameter, that is to say, varying within a limited and clearly identified interval relative to the results provided by an integral analysis of noise; to precise the duration of that measurement in order to achieve the referred objective, during daytime and nighttime. The strategy adopted was to idealize a new describer that could be used as a performance evaluation criteria for the chosen time intervals, called the Significant Measurement Starts (SMS). This represents the probability that a single measurement, with a given duration, started in a pre-defined time interval, can provide a significant result. A SMS equal to 0.50 was set as the minimum value from which a time interval could be considered suitable to be held as a preferred time interval to start a measurement. Different conclusions were achieved both for day and night periods and for weekdays and weekend days. The potential uncertainty of performing random measurements was also investigated.

INTRODUCTION

The urgent need derived both from the new Portuguese legislation [1] and European directive [2] to define a strategy for monitoring noise levels and subsequently elaborate noise maps at a municipal level faces, in Portugal, with a huge difficulty related with the resources involved, both human and equipments, which would result in an unaffordable budget surcharge for the Portuguese municipalities.

For that reason it is desirable the development, for some typical urban "scenarios", of an expedite methodology for assessing noise levels, creating a database from which it would be possible to infer the cyclic variations of noise levels to another "scenarios" with similar characteristics. This concept, named of "acoustic scenarios", was already presented in previous works [3, 4].

In this paper a new acoustic scenario is introduced, for which it was developed a new evaluation strategy based on a new parameter named "Significant Measurement Starts" (SMS). The results presented are referred to the two reference periods defined in the Portuguese legislation [1], the daytime period (7:00 to 22:00 h) and nighttime period (22:00 to 7:00 h) and to the evaluation parameter also set in the same document: the equivalent A-weighted continuous sound level, L_{Aeq}.

METHODOLOGY

In order to assemble an amount of measurements that would allow accomplishing feasible conclusions on the L_{Aeq} cyclic variations, the one-minute L_{Aeq} values were stored uninterruptedly for about one month, in order to have at least three measurements per day. The equipment used in this work was a B&K 2231 sound level meter (with the "Short-term L_{Aeq}" software) connected to an outdoor microphone B&K 4184. The microphone was placed 2 m from the facade, measuring a backyard in the centre of Porto, the new "acoustic scenario".

From the measured "instantaneous" (1-min) values, daily mean values were calculated for each minute and for the same day of the week. The $L_{Aeq,T}$ (T = measurement duration) was then calculated according to the expression (1).


Figures 1 & 2. Outdoor microphone installation and sight of the measured backyard

$$L_{Aeq,T} = 10\log_{10}\frac{1}{T}\int_0^T 10^{\frac{ShortLeq(t)}{10}}dt \quad (1) \qquad \text{used as:} \qquad L_{Aeq,T} = 10\log_{10}\frac{1}{T}\sum 10^{\frac{ShortLeq(t)}{10}} \quad (2)$$

Afterwards, the next hypothetical real measurement situation was conjectured from which it was deducted the "Significant Starts Measurements" (SMS) parameter. When an operator carries out a measurement at one location, he/she can start it at any time of the day and he/she can also perform it during an undefined time interval. If we evaluate all the possible measurements results (for a given measurement duration) using equation (2) we will be able to compare these results with the whole period L_{Aeq} evaluation and check for their significance. Establishing a maximum admissible variation for the potential measured values, we can compute the probability that any random measurement, started at any minute of the reference period with a given duration, fall within the set pre-defined significance interval. This probability is what was called the SMS parameter. Therefore, the SMS is a numerical value that varies from 0 to 1.

In order to define, during both day and nighttime periods, the preferred time intervals to start a expedite measurement, the SMS values were computed for pre-defined 30 minute time intervals covering the 24 hours of each day. The acceptance criterion was that a preferred time interval should have an SMS at least equal to 0.50.

One major difficulty has to do with the possible seasonality of the noise emissions, clearly seen in [5] that would influence the all-period L_{Aeq} value. Nevertheless, it may be expected that even if the real L_{Aeq} value oscillates during the year, the best evaluation time intervals will remain approximately constant.

RESULTS AND ANALYSIS

General Data Interpretation

Firstly, it is imperative to characterize in a suitably manner this new "acoustic scenario". As stated before, we measured a backyard noise environment in the centre of Porto (Portugal), with the main noise source derived from Álvares Cabral Street traffic emissions. At this thoroughfare approximately 1,200 vehicles/hour circulate during daytime (rush-hour), and at nighttime less than 600 vehicles/hour (between 22:00 and 00:00 h) - Fig. 3. Between 00:00 and 5:00 h this number reduces to less than 200 vehicles/hour (about 3 vehicles/minute). The results of traffic daily counting are presented on the chart in figure 3 where it is also shown the maximum traffic variation during one week.

These data, gently provided by the Porto Municipality, are of major importance to extrapolate the results of this work to other sites with similar traffic profiles, i.e., to equivalent "acoustic scenarios". We should note that, fortunately, there was not any relevant "parasite" noise source (ex: industrial plant) apart from the thoroughfare mentioned, which enhances the extrapolation probability.

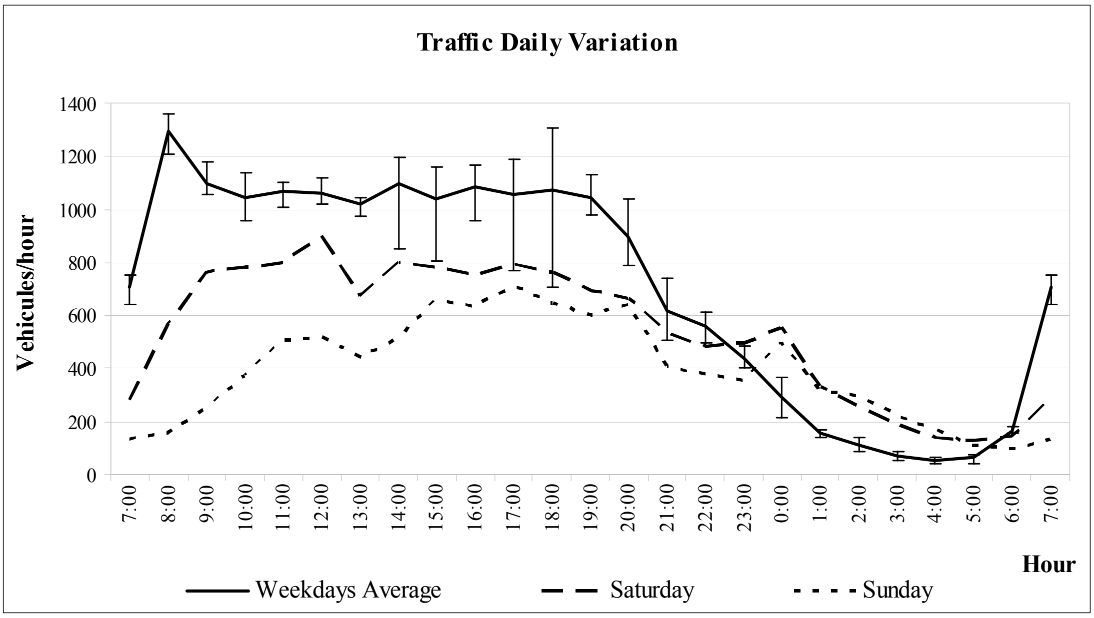

Figure 3. Characterization of the traffic daily variation in this acoustic scenario

L_{Aeq} (dB)	Monday	Tuesday	Wednesday	Thursday	Friday	**Weekdays**
Daytime	55.9	56.0	56.0	55.1	55.5	**55.5**
Nighttime	50.1	50.7	51.0	50.9	51.2	**50.4**
Difference (= dayt. - nightt.)	5.8	5.3	5.0	4.2	4.3	**5.1**

Table 1. Summary of the L_{Aeq} results obtained for weekdays

Concerning the noise profiles obtained, the table 1 displays the summary of the analyses done for the L_{Aeq} of the different days and the comparison with the weekday's average.

It appears to exist some homogeneity on the daily global L_{Aeq} results, with an overall maximum deviation of 0.9 dB(A). Consequently, it seems coherent to define a typical weekday profile, based on the average results of all measurements performed. Nevertheless, when that is done, it should also be examined the interval of confidence for the weekdays average L_{Aeq} (see figure 4).

As it may be realized from inspecting the figure 4, the 95% confidence interval for L_{Aeq} measurements (for the entire reference period) is 50.4 to 61.9 dB during daytime (a 11.5 dB amplitude) and 44.7 to 57.4 dB during nighttime (a 12,7 dB amplitude). Apart from the potential dispersion of performing random measurements, it was also concluded that the accuracy for daytime measurements is better than for nighttime.

For weekend days, the L_{Aeq} results obtained (day/night respectively) were 55.1/50.9 dB(A) for Saturday, and 55.6/51.5 dB(A) for Sunday.

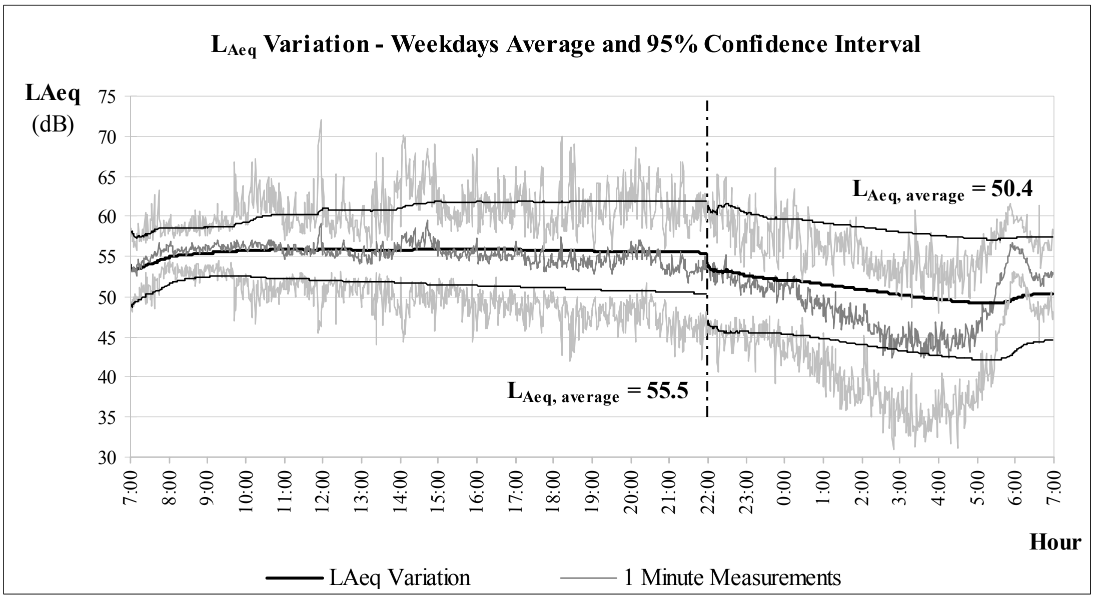

Figure 4. Weekday average L_{Aeq} variation profile and 95% confidence interval

Preferred Measurement Time Intervals and Measurements Duration

The major intent of this work was the definition of the preferred measurement time intervals and the specification of their measurement duration. In order to do so, we computed the SMS parameter for pre-defined 30 minutes time intervals (15 minutes measurements duration) for all daytime and nighttime periods, checking for concentrations of SMS greater than 0.50 among those intervals, for a given maximum error (± 0.5 or ± 1.0 dB(A)).

In Figure 5 the spreading of SMS values during daytime periods seen, with a maximum error of ± 0.5 dB(A). It is quite evident from that figure that the time interval [8:00; 8:30 h] is clearly the most appropriate to perform measurements during daytime period (for weekdays). It is also concluded that the "morning period" (between 7:00 to 14:00 h) gives typically more accurate results than the afternoon and evening ones.

Using a similar approach for the nighttime period, the results obtained were not as satisfactory as the previous ones (see figure 6).

In fact, in this case it was not possible to identify any time interval having, for any day of the week, an SMS value equal or greater than 0.50, with an error of ± 0.5 dB(A). So, the solution was to extend the maximum tolerable error to ± 1.0 dB(A) and to see the consequences on the SMS values obtained (figure 7).

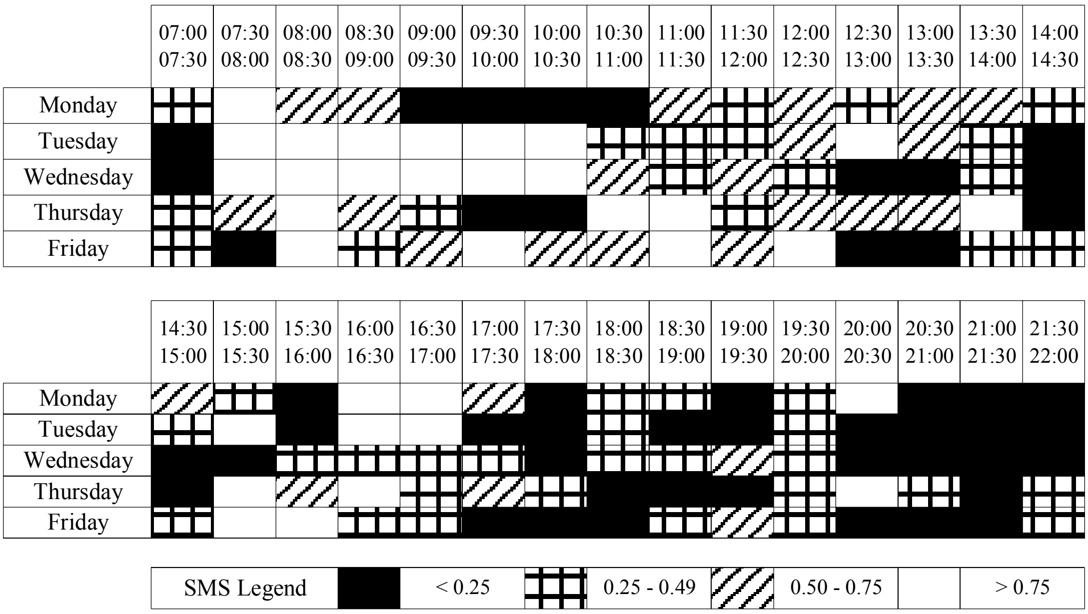

Figure 5. SMS variation in four groups of values within pre-defined time intervals - daytime period (allowable error ± 0.5 dB(A))

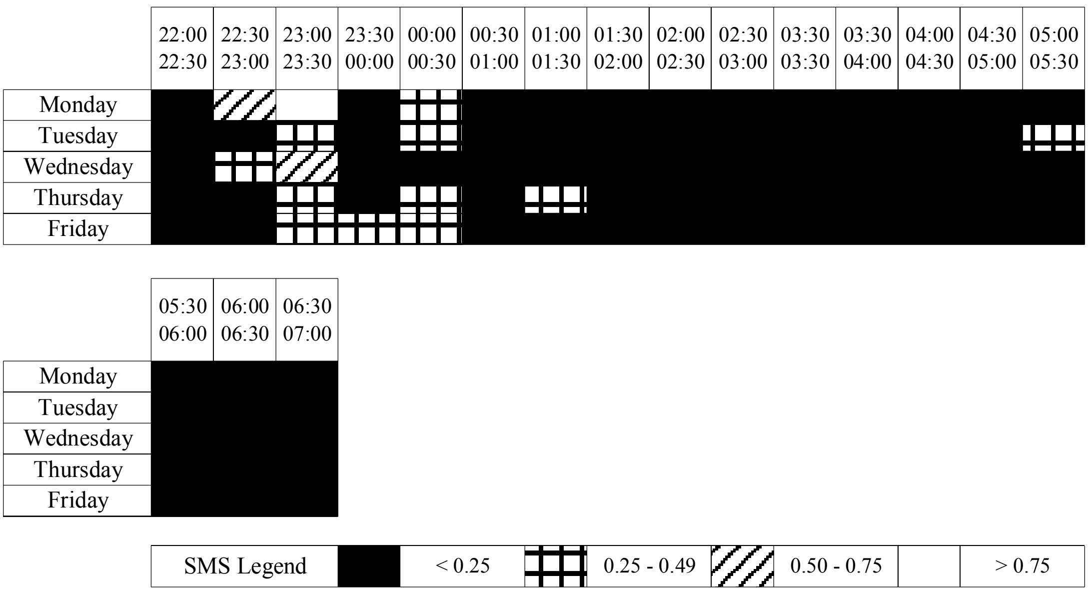

Figure 6. SMS variation in four groups of values within pre-defined time intervals - nighttime period (allowable error ± 0.5 dB(A))

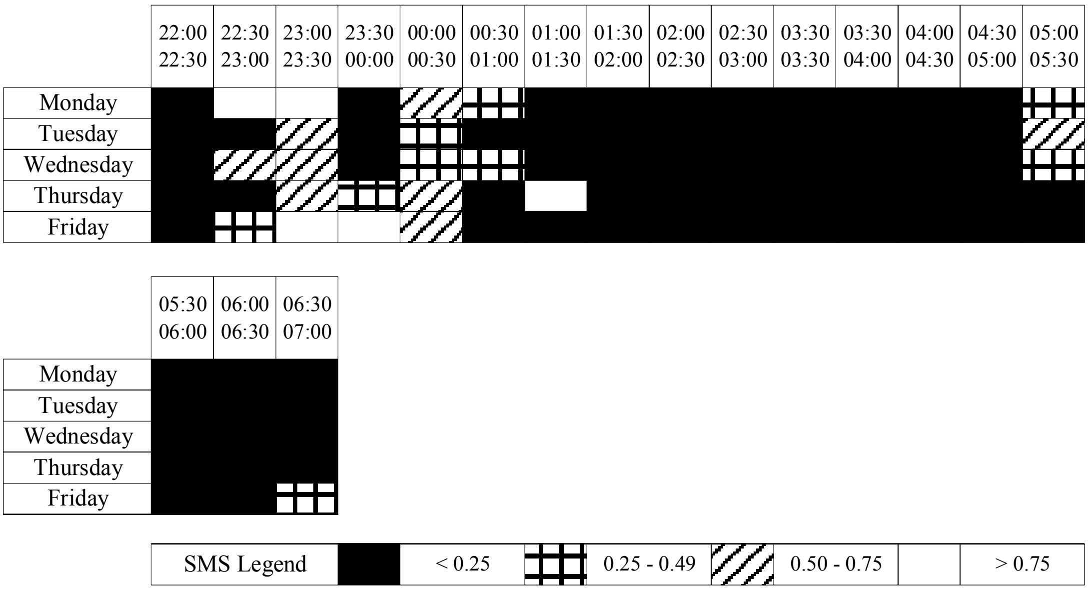

Figure 7. SMS variation in four groups of values within pre-defined time intervals - nighttime period (allowable error of ± 1.0 dB(A))

As expectable, the tolerable error enlargement was enough to identify a preferred time interval for starting significant measurements. This inference is somehow revealing of the large dispersion evidenced by nighttime measurements relative to the daytime ones, which corroborates the results provided by the 95% confidence interval analysis. It is also important to notice that any measurement started after 00:30 h would probably lead to an erroneous result.

In relation to the measurements most suitable duration, the conclusions were not so noticeable. In fact, it was noticed that during daytime, the SMS parameter increases progressively as the measurement duration is extended. It was found that in order to have at least one pre-defined time interval with an SMS equal to 0.95 for all weekdays, 15 minutes measurements were needed.

For the nighttime period the results obtained were quite different. For this period it is not possible to affirm that the measurements accuracy is directly proportional to his duration, because an excessive prolongation of measurement duration leads to a progressive divergence from the measured results to the actual all-period L_{Aeq}, resulting in misleading estimations. Measurements with a duration that varies from 5 to 15 minutes were found to be the most adequate for this period.

SUMMARY

The use of SMS parameter proved to be very efficient to define preferred time intervals for start significant measurements in a new “acoustic scenario”. It was also realized that using this parameter the measurements duration during nighttime period should not be prolonged for more than 15 minutes, diverging from the daytime period, where the measurements accuracy typically increase with their time extension.

The expedite methodology developed could be stated as follows in Table 2.

Day	Period	Preferred Time Interval (h)	Averaged SMS Value	Error (dBA)	Measurement Duration (min.)
Weekdays	Daytime	08:00 - 08:30	0.86	0.5	15
	Nighttime	23:00 - 23:30	0.75	1.0	15
Saturday	Daytime	12:30 - 13:00	0.97	0.5	15
	Nighttime	23:00 - 00:30	0.66	0.5	15
Sunday	Daytime	11:00 - 11:30	0.73	1.0	15
	Nighttime	00:00 - 00:30	0.53	1.0	15

Table 2. Expedite methodology summary for the introduced "acoustic scenario"

ACKNOWLEDGMENTS

We would like to express our gratitude to Mr. António Costa (LAIC), for both his friendship and technical support throughout this work.

REFERENCES

[1] "Regime Legal Sobre a Poluição Sonora" (in Portuguese), DL 292/2000 (Portuguese Noise Code)

[2] "Avaliação e Gestão do Ruído Ambiental", (in Portuguese), European Directive 2002/49/CE

[3] A. Carvalho, R. Rodrigues, "Expeditious noise mapping at a municipal level", Proceedings "Inter Noise 2000", Nice - France (2000)

[4] R. Rodrigues, A Carvalho, "Practical methodology for fast environmental field measurements", Proceedings "Forum Acoustics", Seville - Spain (2002)

[5] Gimenez Gaja, "Sampling techniques for the estimation of the annual equivalent noise level under urban traffic conditions", in Applied Acoustics, **64,** 43-53 (2003)