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EXPEDITIOUS NOISE MAPPING AT A MUNICIPAL LEVEL

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ABSTRACT
The 1987 Portuguese Noise Code requires noise zoning using the L_{A50} parameter in two periods (*day* and *night*). The new Portuguese Noise Code (to be published soon) will use the parameter L_{Aeq} for the same periods and purposes but enforces the municipalities to determine their noise maps. This will be a huge task for the 307 municipalities. Therefore there is a need to find a fast but valid method to perform that work with not many means in equipment or manpower. This paper describes recent studies in order to find such expeditious model. Work has been done to characterize and group municipal sound fields in "acoustic scenarios", to discuss the minimum measuring time to give reasonable and representative global results for those parameters. The result of this study is an expeditious and low cost method for noise mapping in large areas using few resources.

1 - INTRODUCTION
The analysis of large sound fields, for instance at a municipal or regional level, has certain problems. One of the most important is the spaciously vast task that would require such a large quantity of resources that would make almost unfeasible any intent to characterize those areas.
In Portugal, by force of the Portuguese Noise Code (*Regulamento Geral sobre o Ruído*, RGR, DL 251/87), there is the legal need to know, on a municipal level, the "noise rating" or "noise zoning". In the RGR (art. 4) the noise zoning regarding building available areas must be done using the L_{A50} and in two time reference periods (day: 7 to 22 h and night: 22 to 7 h). The future version of this law (expected to be published soon) will change the parameter used to the L_{Aeq} (and using the same reference periods).

NOISE ZONING	*lowly noisy*	*noisy*	*highly noisy*
L_{A50} (7-22 h) dB	≤ 65	≤ 75	others
L_{A50} (22-7 h) dB	≤ 55	≤ 65	others

Table 1: Noise zoning (Portuguese noise code).

In a general way, the main goal of the work is to characterize very large sound fields dealing with the following difficulties:

- Large variability, in space and time, of the noise emissions;
- Season dependence of many noise sources;
- Noise propagation conditioned by topography, building environment, climate, absorption characteristics of the surrounding surfaces and ground, etc.;
- Cost and specialization of the means required for field measurements;

The goal is to develop a methodology to identify large sound field giving special attention to the results reliability and reproducibility as to the possibility to serve as a basis for an acoustical characterization of great areas.

2 - EXTERIOR SOUND FIELDS – ACOUSTIC SCENARIOS

2.1 - Methodology for sound field characterization

The main difficulty initially found that created the lead motif that identified the need for "acoustic scenarios", had to do with the lack of data reproducibility when acoustically characterizing an area. To make this characterization there are basically two main families of methods: The one associated to the spatial definitions of the measurements positions and that associated with the measurements duration in time (Table 2). It is also possible to define a mixed methodology of these two following the specifics of a particular situation under study.
It is also frequent the use of another family of methods to characterize sound fields by the mathematical simulation done after noise source identification and characterization. In this case, dedicated software is usually used and has only particular interest in noise mapping of very limited areas because they require the knowledge of detailed information about all the noise sources (sound power, etc.) that is not usually accessible.

Spatial definition / Measurement duration	**e1** – rigid network of measurement positions	**e2** – variable network of measurement positions
d1 – Full-time measurement	d1e1	d1e2*
d2 – Particular measurement in fixed intervals	d2e1*	d2e2**
d3 – Variable measurement	d3e1**	d3e2*****

Table 2: Two families of methods for sound field characterization (* shows the frequency of use for these methods).

2.2 - Procedure

To define the acoustic scenario a few measurement positions were selected to make full measurements in order to understand the sound field behavior. The main conclusions of this phase have to do with the following aspects:

- Several positions with large data correlation and other with very small correlation;
- Data specifics related with the day of the week;
- Large importance of the climate (rain, wind, etc.);
- Precise identification of the main sound sources (road transport noise, railway noise, aircraft noise, localized industrial, rural or commercial noise sources, season dependent activities: construction sites, fairs, etc.);
- Large similarity among "noise signatures" of similar zones.

This last conclusion, the presence of a large number of zones in which the noise parameters have similar behavior in one specific time period, pushed the research for answers to the following questions:

- Is it possible to make a pattern for the ambient noise level characteristics in some zones by relation to other metrics or parameters than the ones measured?
- Is it possible to use socio-geographic data as maps, traffic counting data, industrial and demographic metrics, etc., to infer the ambient noise level behavior and therefore its acoustic zoning?

To be possible this methodology, the problem of characterizing very large sound fields could be simplified. The use of indirect methods could lead to an economy of cost and time. In a second step, the use of digitized data could lead the way to the use of "acoustic" layers dedicated to noise zoning or noise planning.

2.3 - Results

The initial conclusions support that, for at least the majority of an analysis on a municipal level, acoustic scenarios are clearly identifiable by the use of the following indirect parameters: population by parish, presence of main thoroughfares roads crossing the parishes (need to characterize traffic volume data), presence of industrial noise sources and average building height surrounding roads.

Three acoustic scenarios were already identified (Table 3). At a municipal level the accuracy of the model is very good (only in minor situations at a parish level, significant errors were found). This holds true if there is only the need for noise zoning and not for noise mapping of precise noise level contour lines. This procedure is very useful to identify the 3 noise zones under the rules of the Portuguese Noise Code. The scenarios present in Table 3 make possible in an easy and fast way to identify noise zones regarding only statistical data and little more than a visual analysis. These decisions can always be validated by sampling using field measurements, as far as the time and resources allow.

Descriptor	**SCENARIO 01**	**SCENARIO 02**	**SCENARIO 03**
	suburban crossroads	*rural suburban*	*main urban road*
Population by parish	[5000, 25000] inhabit.	[5000, 25000] inhabit.	[5000, 25000] inhabit.
Main thoroughfares	Rush-hour traffic $\leq$ 80 veh./min, 12% heavy traffic	Rush-hour traffic $\leq$ 10 veh./min, 12% heavy traffic	Rush-hour traffic $\leq$ 120 veh./min, 8% heavy traffic
Industrial sound sources	Variable with no implication in the area	Variable with no implication in the area	Variable with no implication in the area
Average building height and occupation in surrounding areas	$\leq$ 8 m 50% occupation	$\leq$ 8 m 50% occupation	$\leq$ 15 m 85% occupation
Daytime reference period ($7 - 22$ h)	$\boldsymbol{L}_{A50} = 55 \pm 3$ dB $\boldsymbol{L}_{Aeq} = 63 \pm 3$ dB	$\boldsymbol{L}_{A50} = 31 \pm 2$ dB $\boldsymbol{L}_{Aeq} = 33 \pm 2$ dB	$\boldsymbol{L}_{A50} = 68 \pm 1$ dB $\boldsymbol{L}_{Aeq} = 71 \pm 1$ dB
Night time reference period ($22 - 7$ h)	$\boldsymbol{L}_{A50} = 41 \pm 4$ dB $\boldsymbol{L}_{Aeq} = 27 \pm 3$ dB	$\boldsymbol{L}_{A50} = 18 \pm 1$ dB $\boldsymbol{L}_{Aeq} = 19 \pm 1$ dB	$\boldsymbol{L}_{A50} = 59 \pm 3$ dB $\boldsymbol{L}_{Aeq} = 65 \pm 2$ dB
Zoning (RGR)	*lowly noisy*	*lowly noisy*	*noisy*

Table 3: Characterization of the acoustic scenarios of simplified analysis of large sound fields.

3 - CONCLUSIONS

It is possible to classify large sound fields using indirect methods using certain demographic data. Such a classification is more reliable if the only goal is to divide a large region in "noisy areas". It was found that is possible to make field measurements during time periods much smaller than the conventional reference time periods, with very good results. For the "acoustic scenarios", the simplified method for field measurements can be done as follows:

Scenarios	**Period**	**Measurement duration**	**Intervals for sampling time**
01	*daytime*	$\approx$ 3 minutes	$8.00 - 8.20$ h or $18.00 - 20.20$ h
	nighttime	$\approx$ 3 minutes	$0.00 - 0.20$ h
02	*daytime*	$\approx$ 3 minutes	$12.30 - 13.00$ h or $17.30 - 19.00$ h
	nighttime	$\approx$ 3 minutes	$23.30 - 0.30$ h
03	*daytime*	$\approx$ 3 minutes	$10.00 - 21.00$ h
	nighttime	$\approx$ 3 minutes	$5.30 - 6.40$ h

Table 4: Simplified sampling method for the three acoustic scenarios.

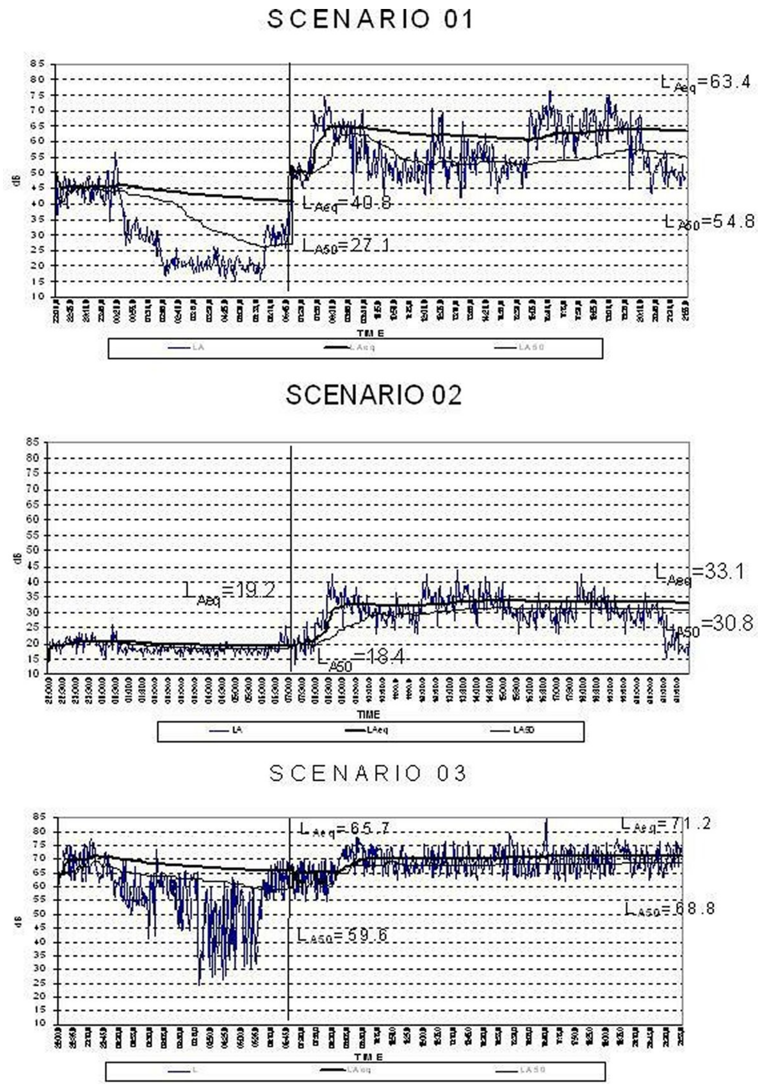

Figure 1: Three acoustic scenarios.