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LOOKING FOR NEW ACOUSTIC INDICATORS FOR URBANISED AREAS

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Summary: The main objective of the paper is to define new indicators of urban ambient noise that supplement more general ones currently in use, designed to evaluate human perception and its changes as a function of the site typology and human perception.

Keywords: transport noise, acoustic indicators, human perception.

1. INTRODUCTION

Even when relatively high, acoustic background is fairly steady, and its level ranges around a certain fixed value. Although the impact of such noise may have harmful effects on health, the human ear gradually adjusts to it.
The reaction to a sudden noise event whose level is high differs significantly even if the event is only momentary. Its reception is particularly unpleasant during the night-time rest when passing cars or motorcycles cause sleep disturbance. The manner in which such noise occurs, its increase rate and its level determine its reception by the recipient exposed to it.
Recent European policy regarding noise pollution is to work towards the harmonisation of data analysis methods. In order to remedy the problem of the diversity of laws and methods, the European Community adopted a directive on the management of ambient noise on the 25th June 2002 [1], making it mandatory to study and analyse all urban areas with more than 100000 inhabitants in order to offer a diagnosis of the noise climate for the definition of European action plans. Thus, a general map of different noise situations will be made using the same methods and indicators. L_{den} and $L_{Aeqnight}$ are two selected indicators. $L_{Aeqnight}$ is the long time linear average root mean square sound pressure level over the night period, and L_{den} is also an energetic indicator, which combines the L_{Aeqday}, $L_{Aeqevening}$ and $L_{Aeqnight}$, using weightings of 5dB(A) for the evening period and 10dB(A) for the night period (Position paper on EU noise indicators). Still, the directive advocates the use of supplementary indicators when the noise situation demands it.
Such indicators are useful in obtaining an overall view on the noise exposure of the populations, drawing sound maps and determining noise problems globally. Despite these advantages, these indexes are not suitable for describing people's perception because they cannot take into account all important details of urban soundscapes (noise events, spectral content, fast fluctuations, etc.). A great number of complaints concerning noise despite the fact that energetic indexes are below the legal threshold proves it.
Thus, if politicians utilise noise indicators which allow for a global description of noise situations (for a big area and long-time periods), they have no tools to describe specific details of the perception of acoustic nuisances which are mostly local and time-varying problems. This is the problem we would attempt to solve.

2. ACOUSTIC BACKGROUND VERSUS NOISE EVENTS

The issues considered below address the problem of increased human sensitivity to short-term noise, so-called susceptibility period. This may be an entire night, accepted to be 8 hours pursuant to Directive 2002/49/EC, or separate, shorter periods when sensitivity to random noise events is particularly high, such as 2 hours at the beginning of the night or 2 hours at the end of the night).
Each event whose noise level exceeds the level of the acoustic background is defined as an acoustic event.
If the time period under consideration is T_s and the duration of individual noise events is t_i, then for the *n* number of events:

$$T_s = T_{ev} + T_p \quad (1)$$

where:
T_{ev} – total duration time of all acoustic events arising in the period T_s.

$$T_{ev} = t_{ev1} + t_{ev2} + t_{ev3} + ... + t_{evn} = \sum_{i=1}^{n} t_{evi} \quad (1a)$$

T_p – total duration time of the breaks between acoustic events.

$$T_p = t_{p1} + t_{p2} + t_{p3} + ... + t_{pn} = \sum_{k=1}^{m} t_{pk} \quad (1b)$$

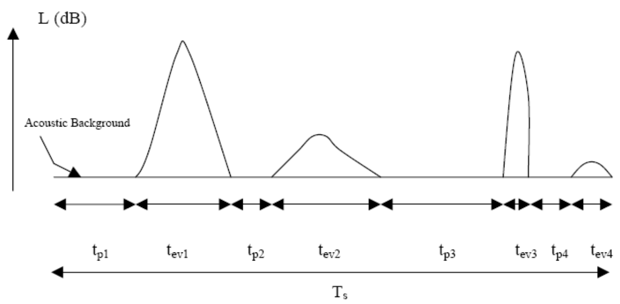

Fig. 1. Formula (1) presented graphically

3. PROPOSED NEW QUANTITATIVE-QUALITATIVE INDICATORS ASSESSING THE ACOUSTIC CLIMATE OF URBANISED AREAS; INDICATORS „*B*” AND „*B&B*”

3.1. General structure of indicator „*B*”

The indicators referred to in Directive 2002/49/EC belong to so-called energetic indicators. Both energetic elements and human perception of short-term, random noise events are accounted for in the new indicator.
Two relatively simple indicators were used: ***NNE*** (Number of Noise Events) and noise increase rate. The former is a commonly known indicator defining the number of acoustic events in the time period under consideration; the latter, noise increase rate $V_{\Delta L}$, is expressed in dB/s [3].
Each event is characterised by a different energetic value and a different course in time (see fig. 1). Both energetic values and dynamic values are mutually interconnected in $V_{\Delta L}$.

Each arising event may thus be characterised by its increase rate ($V_{\Delta L}$), and indicator ***B*** for the analysed urbanised area may be written as a function of 2 simple indicators:

$$B = f\left(NNE, V_{\Delta L}\right) \quad (2)$$

3.2. NNN classification

For practical reasons, it is suggested to classify the indicator reflecting the number of events in a few groups. A preliminary division into 4 groups was accepted. The nuisance factor is different for each group:

Table 1. Classification group in function of number of events

Classification group (class)	Number of events in time Ts
I^n	1÷3
II^n	4÷6
III^n	7÷9
IV^n	≥10

3.3. $V_{\Delta L}$ classification

For the purposes of this study, the increase rate was also classified in 4 groups whose noise factor differed: (Table 2).

Table 2. Classification group in function of increase rate $V_{\Delta L}$

Classification group (class)	Number of events in time Ts
I^v	<3
II^v	3÷8
III^v	9÷15
IV^v	≥ 15

It should be noticed that, as the examinations and analyses [4] demonstrate, the perceived noise level is higher than the actual one if the increase rate of the noise level in the acoustic signal ($V_{\Delta L}$, dB/s) is greater than 15 dB/s. It is caused by unconditioned reflexes of the recipient and the lack of time to assess the situation rationally: a reaction of fear. Moreover, such a high $V_{\Delta L}$ indicator may occur in limited cases, for instance in the vicinity of airports were aircraft emit noise from a small height.

3.4. Combining *NNE* and $V_{\Delta L}$ classes

If a table with two entries (4 classes for each indicator; see Table 3) is designed and numerical values are assigned to each cell in the way corresponding to the situation (starting from cell I^n I^v), then it is possible to develop a classification of individual situations on the scale of 1 to 8 points in 16 different situations.

Table 3. Combining NNE classes with $V_{\Delta L}$ classes

	I^V	II^V	III^V	IV^V
I^n	1	2	3	4
II^n	2	4	5	6
III^n	3	5	6	7
IV^n	4	6	7	8

As the above table shows, some situations, although different, are equivalent as they have the same number of points (Table 4).

Table 4. Equivalent cells

Number of points in cell	Number of equivalent cells	Equivalent cells
1	1	I^n I^V
2	2	II^n I^V; I^n II^V
3	2	III^n I^V; I^n III^V;
4	3	II^n II^V; IV^n I^V; I^n IV^V
5	2	III^n II^V; II^n III^V
6	3	IV^n II^V; III^n III^V; II^n IV^V
7	2	IV^n III^V; III^n IV^V
8	1	IV^n IV^V

3.5. Classification of urbanised areas according to criterion *"B"*

It is possible to classify urbanised areas on the scale of 1 to 25 points (Table 5) on the basis of Table 3, also taking into consideration all possible situations that may occur in the time analysed T_s.

Table 5. Classification of urban area

Number of points	Class symbol	Urbanised area class
1÷5	A	Good
6÷10	B	Fairly good
11÷15	C	Mediocre
16÷20	D	Bad
21÷25	E	Very bad

An area is defined as very good if no acoustic events occur in it (0 points).

3.6. Indicator *"B"* determined over a long period of time – indicator *"B&B"*

The above manner of determining indicator „*B*" serves only to asses an urbanised area in the period under consideration of a single time period T_s (for instance 2 hours). However, as energetic indicators are determined over a long period of time (specifically one year) according to the European Directive, it would be recommended to consider the developed indicator over a similar time period.

Its nature would then be statistical, and it would express the occurrence frequency of individual classes A to E (as given in Table n^{o} 5) of the analysed urbanised areas over a year. It would be expressed in percent - ***„B&B" (%).***

4. PROPOSED SUPPLEMENTARY INDICATOR

An indicator describing the occurrence frequency of acoustic events *(f_a)* in the time period T_s, expressed in percent, as a ratio of the duration of all events until time T_s, could be used as an indicator supplementing the above indicators of the ***"B"*** types.

$$f_a = \frac{T_{ev}}{T_s} \qquad (3)$$

where:
T_{ev} , T_s – see formula (1).

5. CONCLUSION

This document proposes the idea of new indicators to assess urbanised areas from the point of view of the acoustic climate.
The proposed classification given in Tables 1 – 5 should be treated as preliminary. The proposed categories will be verified using simulation calculations conducted for virtual sites (for instance L-type street, U-type street, city square, etc.) and for real sites (calculations or/and noise measurements) in the next stage of the project.

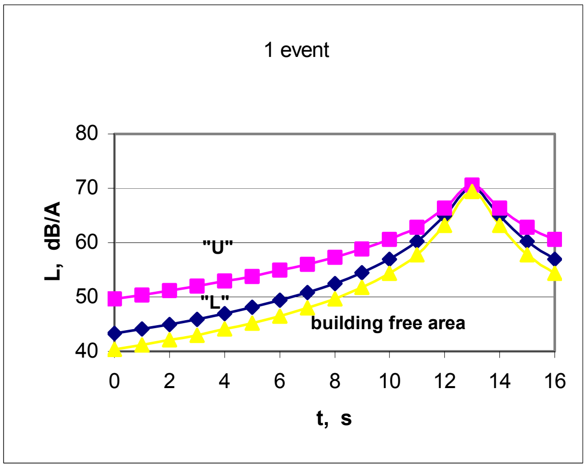

Fig. 2. Noise level changes at the receiver point as a function of time. Influence of urban structures [3].

Preliminary calculations [3] conducted so far demonstrate that there exists a certain differentiation of the perception of the same acoustic event as a function of the structure of a built-up area (Fig. 2 and 3).

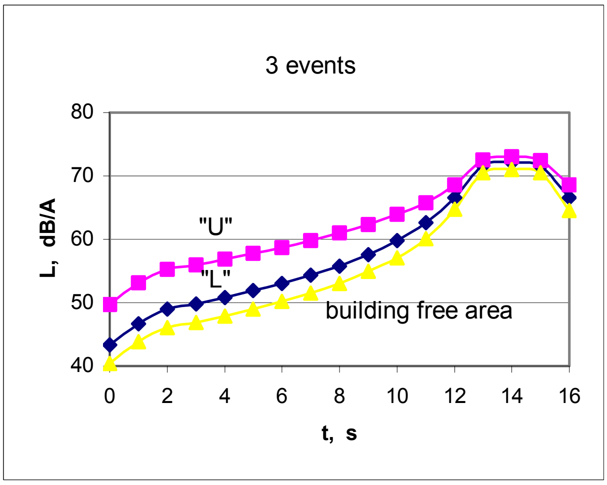

Fig. 3. Noise level changes at the receiver point as a function of time. Influence of urban structures [3].

A significant differentiation of increase rate $V_{\Delta L}$ (dB/s) values and a different time of the occurrence and the duration of an acoustic event as a function of the urban built-up area was observed. It may thus be concluded that the course of the acoustic event depends on the structure of the built-up area.

References

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