Study of various situations of dominance of combined noise sources (road and railway)

Eva Walker[1], Manon Raimbault[2], Catherine Lavandier[3], Cora Cremezi-Charlet[1]

[1] SNCF-DRT - 45, rue de Londres 75379 Paris Cedex, eva.walker@sncf.fr
[2] Inrets-Lte - Case 24, 69675 BRON Cedex
[3] LMRTE Univ. Cergy-Pontoise, Dept. Génie Civil -Rue d'Eragny, Neuville/Oise 95031 Cergy Pontoise

Introduction

Previous studies on the evaluation of combined noise sources (road and rail) show that the distinction of various classes of dominance, i.e. a difference $\geq$ 5 dB between the levels of each source, involves a better prediction of annoyance [1] [2] [3]. Study of situations of combined noise sources distinguishes three classes of dominance: road, railway and in-between (i.e. no-dominance). The problem adressed is to characterise the distinction of situations of dominance : temporal patterns and/or sound level emergences. The present research of new acoustics indices of combined noise sources differentiates the noise source input (i.e road and railway) in order to better calculate their specific patterns. This new approach thus allow to test a broader panel of acoustic descriptors. The aim of this study is to identify the relevant differences between the situations of dominance in order to develop new indicators for the evaluation of combined noise sources.

Method

Measurements of short L_{Aeq} time evolution of 24 hours were selected from a previous study [1]. These data allow the comparison of different periods of the day: 6h-19h, 19h-22h, 22h-6h. In order to improve the evaluation of combined noise sources, situations of dominance were compared for various periods of the day through the analysis of time patterns on graphs of short L_{Aeq} evolution. The graph comparison drew attention to time patterns differences and therefore points to the need of new acoustic descriptors of temporal features.

For the following study, combined noise sources were differenciated considering the coded sources 'train', and 'emergences' for the rest of the signal (with respect to a threshold equivalent to 5 dB above the measured L_{A90}). Various acoustic descriptors were tested for the specific period of 6h-19h : global indices and fractional indices for the coded sources train and emergences for the rest of the signal. Standard acoustic indices were calculated for each coded sources as new indices describing time level's evolution of 'train' or 'emergences' for the rest of the signal. The descriptors used are:

- *global indices:*
  - $\mathbf{L_{Aeq}}$, $\mathbf{L_{min}}$, $\mathbf{L_{max}}$,
  - percentile levels ($\mathbf{L_{A10}}$, $\mathbf{L_{A50}}$, $\mathbf{L_{A90}}$),
  - noise pollution level $\mathbf{L_{np}}$, emergence level $\mathbf{L_{em}}$,
  - **Dom** difference between levels of each source.
- *fractional indices calculated for the coded sources "*t" for 'train' or "*e" for 'emergence':*
  - **SEL*t** and **SEL*e** sound exposure level,
  - $\mathbf{L_{Aeq}S}$ (*t or *e) specific sound equivalent level of the coded sources, over the emerging time period,
  - $\mathbf{L_{Aeq}P}$ (*t or *e) particular sound equivalent level of the coded sources, over the total duration of the signal,
  - **Std** (*t or *e) standard deviation of the sound equivalent level of the coded sources,
  - **%tps** (*t or *e) percentage of emerging time of the coded sources,
  - **Dmoy** (*t or *e) average duration of the coded sources,
  - **Nb** (*t or *e) number of each coded sources.

Five multidimensional principal components analysis (PCA) were made to observe which descriptors better characterised each situation of dominance for the specific period of 6h-19h [4]. Analysis was carried first for each class of combined source situations (8 railway dominance, 10 road dominance and 10 no dominance) and then for all the situations.

Results

Graph comparison

The analyses confirmed that situations of combined noise sources are characterized in various ways depending on their exposure to the noise, since classes of dominance are not only shaped by the difference in sound level (L_{Aeq}) but also by features related to the sound signal itself, such as the peak shapes, the duration, the time evolution, and the level of emergences. The railway and road dominance are thus fairly determined by these characteristics.

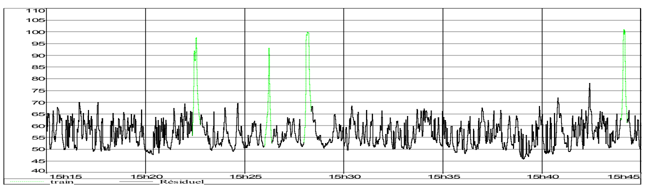

Figure 1: Dominance of railway - Extract of 6h-19h period

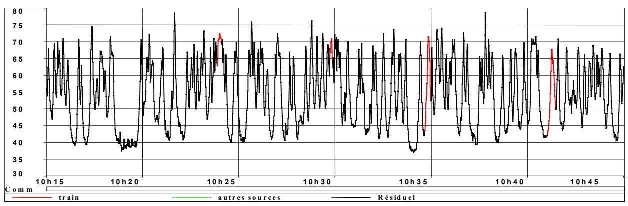

Figure 2: Dominance of road - Extract of 6h-19h period

However the situations with no dominance have different sub-classes according to the position of the roadway and the railway facing the building. Their analysis is then similar either to the dominance of railway or road, depending on the various cases of positioning studied.

At least, the comparison between the different periods of the day shows that the night period is completely different from the others, whatever the dominance classes, because the train's emergence as well as the road's emergence exhibit significant features.

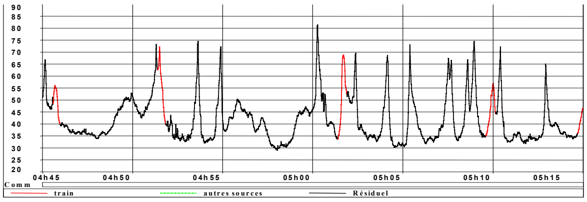

Figure 3: Dominance of road - Extract of 22h-6h période

So, characteristics of temporal criteria for night period are very different from the other periods. This result shows that situation of dominance for a given area can differ according to the considered time period.

Statistical analyses

Analysis of the PCA results shows which of the acoustic descriptors are the more significant for differentiating the observed situations.

The first observation concerns the « DOM » indices which explain the level difference between noise sources. These indices were used to define the classes of dominance and are thus redundant with the label of the situation.

The second comments refer to the analysis for each situation of dominance. The specific equivalent sound level of 'train' ($L_{Aeq}S*t$) stood out of the whole multidimensional analyses for each situation of dominance. This specific descriptor appeared independent of the other acoustic descriptors and steady among all the multi-source (road and railway) noise environments.

The following results speak of the analysis for all situations of dominance. Distribution of the indices mostly differentiates the whole situation according to the sound level variations. We also notice that L_{max} and Nb*t are independent of the other indices but are not relevant for explaining differences between situations.

The analysis shows a high correlation between three measures of sound levels of noise source (either railway or emergence) : $L_{Aeq}S$, $L_{Aeq}P$ and SEL. Knowing that specific equivalent sound level ($L_{Aeq}S$) was calculated independently of time, this specific index was selected among the three indices. Moreover, the %tps*t appears relevant for differentiating various situation of dominance.

In conclusion eight indices appeared more relevant:

- for the global indices: L_{Aeq}, L_{90}, L_{10}, Std,
- for the train and emergence indices: $L_{Aeq}S$, %tps.

Finally, the last multidimensional analysis was carried out with only the eight indices selected. Observation of the results was therefore clearer than with the large panel of acoustic descriptors. Total indices still emerge from the analysis without differentiating the situations according to dominance classes. Concurrently, we observe that train indices ($L_{Aeq}S*t$ and %tps*t) differentiate classes of dominances.

Discussion and conclusion

On the one hand, results show that temporal patterns of situations of combined noise sources are different according to the type of dominance measured. Moreover, the situation of dominance of one area can be different according to the selected period.

On the other hand, multidimensional analyses show that standard acoustic descriptors like global indices (equivalent level L_{Aeq}, L_{max}...) are insufficient for characterizing the differences between varied situation of dominance.

Finally, eight descriptors were noticeable among the whole multidimensional analyses: %tps*t, $L_{Aeq}S*t$ and L_{Aeq} for railway dominance; %tps*e, L_{90} and $L_{10,}$ $L_{Aeq}S*e$, and Std for road dominance.

Nevertheless, situations of no dominance seem to be more complex to characterize as no index clearly stood out and situations of no dominance cannot be classified either as a part of road or rail dominant classes or a separate class.

Taking into account the few studied situations of no dominance it's difficult to voice more conclusions about these varied situations.

References

[1] Champelovier P., Cremezi C., Lambert J., E*valuation de la gêne due à l'exposition combinée aux bruits routier et ferroviaire*, Rapport INRETS-LTE/SNCF n°0124 (2001).

[2] U. Moehler, M. Liepert, "Différences in the annoyance between rail and road traffic noise in relation to the acoustic situation", *Internoise* (2000).

[3] D.Schreckenberg, A.Schumer-Kohrs, B.Griefahn, U.Moehler "An interdisciplinary study on railway and road traffic noise : Annoyance différences", *Joint meeting of ASA, EAA, DEGA*, Berlin (1999).

[4] Raimbault M., Lavandier C., Bérengier M., "Sound ambient assessments of urban environments", In: *Applied Acoustics* 64, (2003) 1241-1256.