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Prioritizing Road Noise Protections

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Abstract

Prioritizing action plans on wide road (or rail) networks where numerous complaints ask for noise abatement is a sensitive task. Ministries must have rock-solid arguments and methodologies in order to fix their budget in a fair manner. The developed method uses a two step classification, first measuring the in-situ noise levels; updating traffic data's toward a fixed prospective date, and eliminating the less exposed sites. The second step consists on noise mapping of every remaining site. Specific weightings then give a value to a new unit called *ECU* (Exposure Comparison Unit), allowing classification between sites. Advantages of *ECU* are that one can easily cut large sites, or conversely combine small sites between themselves, in order to avoid problems due to the site size, while still keeping a fair comparison between them. Hierarchical lists can be established, based on *ECU*, and then used to plan actions and budget for noise protections. The Ministry of Equipment and Transport of the Walloon Region (Belgium) has classified about 400 different sites representing almost 600 kms of sites from a network of 8000 kms. The hierarchical list is now used not only as a dynamic decision tool for distributing budgets, but also as a dialog tool with the complainants.

1. Introduction

Enlarging road networks, increasing road traffic, and enforcing noise policies forces almost all countries to face a true challenge: the amount of exposed locations worth to be protected widely exceeds the amount of locations for which the corresponding budget is, or will be available. One thus has to schedule a realistic action plan that has to combine the practical and the financial possibilities the relevant authorities effectively do have. In the same time, this action plan should reach not only the agreement of the ministries of environment, but also the agreement of the inhabitants of these exposed locations.

For years, ministries of transport received not only complaints about the road traffic noise itself, but also complaints from people worried that their neighbours are already protected,

while they are not yet... The action plan is then not only a planning tool, but also an important communication tool, for which one must have rock-solid arguments based on irrefutable methodologies.
In the middle of the nineties, the Ministry of Equipment and Transport (M.E.T.) of the Walloon Region (Belgium) decided to prioritize the road noise protections along their 8000 kms main roads network. In order to achieve this objective, it has been decided to establish a hierarchical list that has to grade the importance of exposure to traffic noise between almost 400 exposed sites. One has to note that these sites do not correspond to all the existing exposed sites, but only to sites where some inhabitants have clearly expressed their complaints. Facing budget problems, it was evident to first consider the sites where complaints effectively exist, and not where any complaints have been expressed yet, even if the exposure to traffic noise could be important there. However, this choice may differ from countries to countries, where the exhaustiveness of the list is sometimes preferred.

2. Methodology

The basic principles can be used for road traffic noise as well as for rail traffic noise; the method uses a two steps classification:

1. in-situ measurements of the actual noise and first classification,
2. noise mapping of exposed sites and establishment of the hierarchical list based on the *ECU* (Exposure Control Unit).

While not entering in the formula of calculation of *ECU* presented hereafter (4), in-situ measurements are very important for at least two reasons:

1. people does better believe in measurements than in calculation results that they usually do not trust,
2. carrying out in-situ measurements give an opportunity to certify an existing situation at a fixed date for files.

In this methodology, in addition to facts and figures for files, measurement results are used for a first selection process, eliminating weakly exposed sites, i.e. sites for which the highest noise level measured in the site is : max $[L_{Aeq}(6\text{-}22h)] \leq 56$ dB(A).

The remaining sites are then studied with a "simplified" 3D model: "simplified" because it does not take special effects as meteorological ones into account, but still in 3D because topography plays a important role while we want to compare sites of different topographic regions with the same objectivity.

Finally, a very important point in order to make objective comparisons is that all the results, for measurements as well as for calculated noise maps, do have to correspond to a strictly identical common term for all the compared sites.

3. In-situ measurements

Obviously, the in-situ measurements of more than 400 sites exposed to road noise cannot practically be carried out at the same time; furthermore, a new term is fixed every year in order to update all the data to a single common term for all the sites. Whatever the period of measurement was, or the new term is, corresponding traffic conditions are updated with rather simple formulas:

$$L_{Aeq_{updated}} = L_{Aeq_{meas}} + 10\log_{10}\frac{Q_{eq_{updated}}}{Q_{eq_{meas}}} \quad (1)$$

$$\text{with } Q_{eq_{updated}} = \frac{Q_{(6-22H)}}{100}\left[100 + (E-1).P_{(6-22H)}\right] \quad (2)$$

$$\text{and } Q_{eq_{meas}} = \frac{Q_{meas}}{100}\left[100 + (E-1).P_{meas}\right] \quad (3)$$

where

$Q_{(6\text{-}22H)}$: traffic density (6-22H) Q_{meas}: traffic density during measurements [veh/h]

$P_{(6\text{-}22H)}$: heavy vehicles ratio (6-22H) P_{meas}: heavy vehicles ratio during measurements [%]

And E is the corresponding acoustic factor of equivalence between trucks and light vehicles corresponding to the actual relative speeds of these vehicles.

According to the corresponding building densities, the amount of measurements points may vary, sites where *max* $[L_{Aeq}$ *(6-22h)]* ≤ *56 dB(A)* are then eliminated.

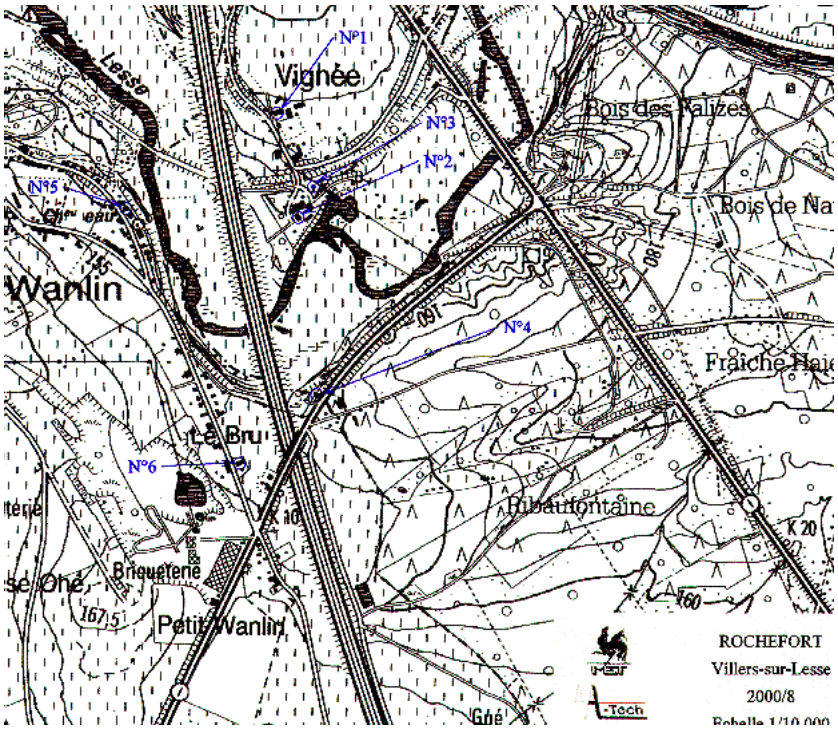

Figure 1: in-situ measurements

4. Exposure Comparison Unit (*ECU*)

If characterizing the sites through their *max* $[L_{Aeq}$ *(6-22h)]* allows to eliminate the less exposed site in a quite objective manner, this indicator is too weak to draw conclusions on the global exposure of a whole site: one effectively can have the following questions:

- How many dwellings are exposed to that *max* $[L_{Aeq}$ *(6-22h)]*: 1 or 200?
- What are the noise levels at the other dwellings?
- For how many houses / dwellings are the complaints justified?

For all those reasons, we defined the Exposure Comparison Unit (*ECU*) which roughly combines the noise levels to which every house or dwelling is exposed in a single value:

$$ECU = 10\log_{10} \sum_{i=1}^{N} 10^{\frac{L_i + L_c}{10}} \quad \text{(without unit)} \qquad (4)$$

where :

N = amount of inhabited houses on site (eventually: amount of apartments in buildings)

L_i = average noise level L_{Aeq}(6-22H) of the area within which the house *i* is located:
- 57.5 dB(A) for the area “55-60 dB(A)”,
- 62.5 dB(A) for the area “60-65 dB(A)”,
- 67.5 dB(A) for the area “65-70 dB(A)”,

or the true L_{Aeq}(6-22H) level if this level is > 70 dB(A).

L_c = Correction factor in order to consider extra care for schools: L_c = + 5 dB(A), or hospitals: L_c = + 10 dB(A)

A site including one single house exposed to L_{Aeq}(6-22H) = 68.4 dB(A) corresponds to an *ECU* = 67.5, while a site including 3 houses exposed to noise levels L_{Aeq}(6-22H) between 60 and 65 dB(A) also corresponds to an *ECU* = 67.3, and a site with 10 houses exposed to noise levels between 55 and 60 dB(A) corresponds to an *ECU* = 67.5. For highly exposed houses, the logarithmic sum gives *ECU* much more influenced by the highest levels than by the lowest: it is evident, but also convenient. Although the levels L_i and L_c are expressed in dB(A), the *ECU* is an indicator including "the houses multiplied by something like the noise level to which they are exposed": one has to avoid any confusion or comparison with noise levels, so we decided to have no unit to *ECU*.

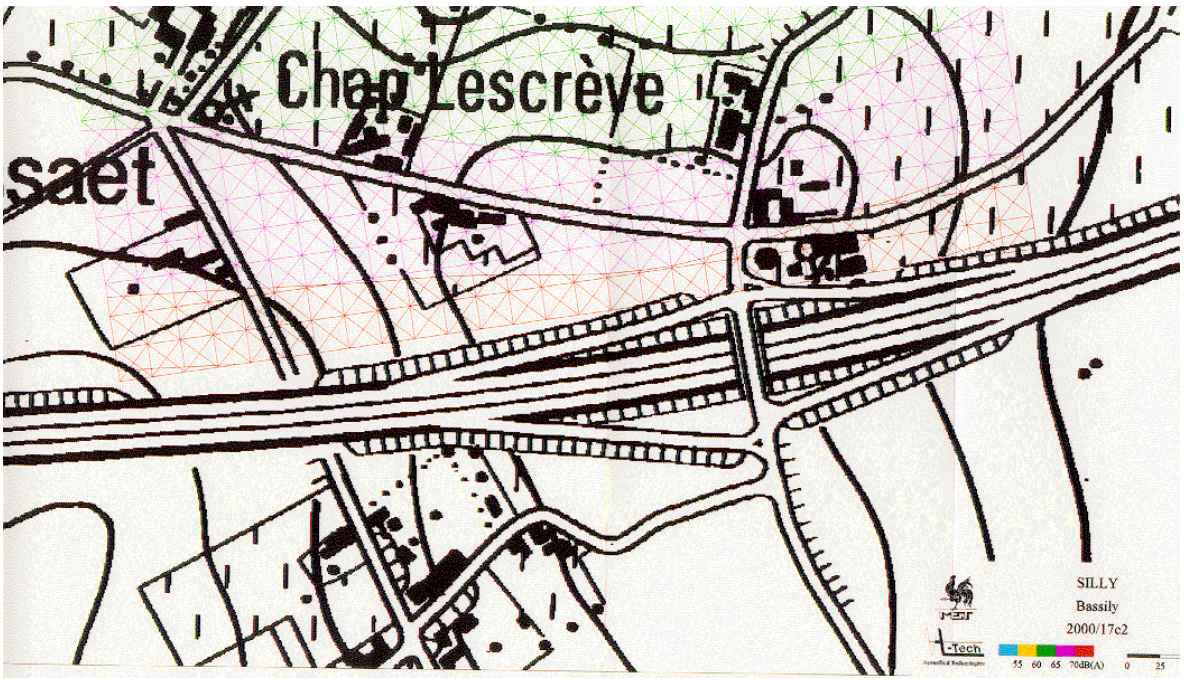

Figure 2: noise map of a typical exposed site with colored noise zones

The table 1 shows an example of *UCE* values on a specified site, with different kinds of exposed buildings:

Table 1: calculating *UCE*

L_{Aeq} (6-22H)	Houses	Buildings (apartments)		Hospital	Schools
> 70dB(A)	4	*		*	*
65-70dB(A)	10	*		*	*
60-65dB(A)	25	40		*	1
55-60dB(A)	32	*		1	*
	Min	Average	Max		
Houses height	R+2	*	R+3		

ECU	84.1

Every house or dwelling has been thus counted for each of the 400 sites, and corresponding *ECU's* give now figures which are quite different than the ordered list we had while using *max [L_{Aeq} (6-22h)]* as indicator: table 2 shows the list using *max [L_{Aeq} (6-22h)]*, while table 1 shows the list using the *ECU* instead, and results are completely different.

Table 1: ordered list using *max [L_{Aeq} (6-22h)]*

	Commune	Site	N°	L_{Aeq} max [dB]
1	Somme-Leuze	Hogne	2000/09	80
2	Liège	Rocourt	2000/73	77
3	Rebecq	Rebecq	2000/47	77
4	Charleroi	Marcinelle	2000/32	76
5	Herstal	Milmort	2000/80	76
6	Messancy	Hondelange	2000/16	76
7	Assesse	Sart-Bernard	2000/01	75

Table 2: ordered list using *ECU*

	Commune	Site	N_i	highway	L_{Aeq} max [dB]	UCE
1	Ans		2000/64	A602	64	92.1
2	Herstal	Milmort	2000/80	A003	76	90.4
3	Li?ge	Rocourt	2000/74	A003	67	90.3
4	Herstal	Vottem	2000/79	A003	67	90.0
5	Li?ge	Glain	2000/66	A602	63	89.8
6	Li?ge	Rocourt	2000/75	A003	66	89.2
7	Gr‰ce-Hollogne		2000/54	A604	68	89.1
8	Li?ge	Rocourt	2000/73	A003	77	88.4
9	Herstal	Milmort	2000/81	A003	65	88.4
10	Li?ge	Glain	2000/68	A602	62	88.1
11	Herstal	Vottem	2000/77	A003	74	87.8

5. The hierarchical list

Based on the *ECU* values of each site, different lists have been drafted: an exhaustive one including all the sites in the Walloon region, and 6 separate ones for every local region having its own budget of protection. Facing budget problems, every local region has the possibility to protect 1 to up to 4 sites: one now better understand the value of the list, what prioritize those sites which have to be protected first. The results of the list(s) also give good arguments for explaining why some sites have to wait further long, and one can really say that people do agree these kinds of arguments, while they previously complained much stronger.

Another big advantage of *ECU* is that one can easily cut large sites into smaller parts, or conversely combine small sites between themselves, in order to avoid problems due to the site size. Thanks to its definition, *ECU* still allows a fair comparison between sites. Many often, some urban sites are effectively too huge to be protected at a single time: dividing these sites into smaller ones avoid to "wait forever" for having enough budget to protect the whole site. Conversely, many small sites may stay at the bottom of the list, while having high levels of noise (but only few houses...): virtually merging several of these sites can give a virtual bigger site which will be displaced higher in the priority list.

6. Protecting the most exposed sites

One has to note that the hierarchical list uses *ECU* as an indicator to classify / prioritize sites: one has avoided to fix any noise exposure criterion for specifying what sites have to be protected or not. The list has the advantage to fix the priorities in a logical scenario combining practical and economical aspects of noise protection. Then, on these sites, noise protections have to be studied in a more accurate way in order to now guarantee the respect of noise exposure criteria. The list has thus, again, new advantages: it prioritizes the detailed studies to be done for designing noise protection. Furthermore, the list is also an excellent tool while fixing new noise exposure criteria, what has always to be done carefully in order to preserve a fair but realistic noise policy.

7. Conclusions

After years of receiving complaints about road noise, the Ministry of Equipment and Transport of the Walloon Region (Belgium) decided to finally establish a dynamic tool allowing them to prioritize noise protection along their 8000 kms main roads network. In-situ measurements have been kept in order to have facts for files, while people are more confident with measurements. A new unit called *ECU* (Exposure Comparison Unit) has been defined which prioritizes quite objectively numerous exposed sites between them, considering "the houses multiplied by something like the noise level to which they are exposed". Hierarchical lists can then be established and be used for a lot of different applications, while keeping rock solid arguments in negotiations.

Acknowledgments

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