ESTABLISHING PRIORITIES FOR GROUND TRANSPORT NOISE IN END ACTION PLANS

Jean-Pierre Clairbois
Acoustic Technologies / A-Tech. 215 Avenue Brugmann. B-1050 Brussels BELGIUM
Email address: jpc@atech-acoustictechnologies.com

Abstract

Every authority managing ground transport networks has problems when establishing noise action plans with (too) numerous exposed sites.

In early 1994, the Walloon region (south part of Belgium) drafted a method using a novel noise exposure index: the *ECU* (Exposure Comparative Unit)[1], in order to already set priorities in their own "noise action plans". Nine years after, the END (European Noise Directive 2004/49/EC)[2] required establishing strategic noise maps and statistics about the exposed population in a very similar way, while not targeting the same level of accuracy than the *ECU*. Today, drafting the END action plans emphasizes the need of an objective and systematic tool to set priorities between numerous exposed sites, but also objectively define the sites themselves.

This paper describes the new ECU_{den} method, which upgrades the previous *ECU* using the latest calculation capacities, the GIS tools, and the attached strategy for drafting noise action plans. This method gives an objective answer to all the concerned parties: ministries of transports, environment, budget, network stakeholders and, of course, the exposed persons. ECU was used since more than 10 years by the Walloon region for highway noise, the ECU_{den} is now used for both highway and railway noise by the Walloon region, but also by the Grand-Duchy of Luxembourg while drafting their strategy for END action plans.

Introduction

Drafting noise action plans, as END requires, includes different considerations as: fixing single or multiple criteria for starting actions (when and where starting actions) and single or multiple criteria for reducing noise (up to what extend and how to reduce it), what is completely different. Those criteria may include acoustic and non acoustic ones, but in any case the strategy must be consistent and clearly demonstrated in a way that the political decisions are objectively motivated.

Prioritizing road noise protection is not a new problem: many European countries did not wait the END directive to develop their own strategies: the Walloon region already defined in 1994 a method based on the *ECU* (Exposure Comparison Unit) using the data and performance of the noise prognoses software of the moment[1]. Since then, softwares and computers have evolved in such a way that we can ask much more details: END and such developments finally lead to a revision of the "old" *ECU* toward an appropriate and updated strategic tool: the ECU_{den}.

The "old" approach

A. Selecting the sites to classify

The old approach considered only those sites where complaints were expressed by the inhabitants: this way was a good argument for saving money, while not considering those sites where no complaint has been raised, even if those sites were highly exposed.

B. The "old" *ECU* for establishing the list

The *ECU* was defined as follow:

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

where :

- N = amount of inhabited dwellings on site
- L_i = the average noise level $L_{Aeq(6\text{-}22H)}$ of the area within which the dwelling *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 exact $L_{Aeq(6\text{-}22H)}$ 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)

The *ECU* was defined on those "sites" / "urban entities" where complaints were effective and were delimited in logic, quite subjective way by the road administration, whatever their length. As far as the *ECU* was such defined, that was not a big problem, as it was easy to assemble contiguous sites or cut ones in parts. Then, the hierarchical list was established and used at the satisfaction of all the concerned parties. On the other hand, the list included the value of the Max $L_{Aeq(6\text{-}22H)}$, an interesting value of how high was exposed the most exposed house, but this value has never been taken into account.

The "new" approach

A. END noise mapping

The END directive requests a systematic approach considering the whole network of roads having more than three million vehicle passages a year for roads (first 6 million for 2007, then 3 million for 2012), and more than 30.000 train passages per year for railways (first 60.000 for 2007, then 30.000 for 2012): this include all the sites, being subject to complaints or not and, even more important, being inhabited or not. But, as the Silence project mentions[3], quantitative noise mapping is only part of the exercise.

The END noise mapping is established with L_{den} and L_{night} instead of the old $L_{Aeq(6\text{-}22H)}$, and the new software are able to calculate the most exposed façade of every single house along roads, so the *ECU* has been modified in such a way to benefit of all those changes.

B. The ECU_{den} definition(s)

The *ECU* advantages were so evident that the Walloon region wanted to keep its concept and adapt it, as well as the Grand Duchy of Luxembourg also start to use it, both for their road and railway networks, as follow:

$$ECU_{den} = 10 * \log_{10} \sum_{i=1}^{N} 10^{\frac{L_i + L_c}{10}} \quad \text{(without unit)}$$

where :

- N = for the Walloon region: the *amount of inhabited dwellings* on site
  for the Grand Duchy of Luxembourg: the *amount of inhabitants* on site
- L_i = for the Walloon region: the exact L_{den} value of the most exposed façade of the house *i*
  for the Grand Duchy of Luxembourg: the exact L_{den} value of the most exposed façade of the house where the inhabitant *i* is living
  in both cases, only L_{den} values greater or equal to 55 are considered
- L_c = Correction factor in order to consider extra care for schools: L_c = + 5 dB(A), or hospitals: L_c = + 10 dB(A); NB: this factor is still subject of discussions

One can see the difference between the strategies in the Walloon region, considering dwellings to protect, and the Grand Duchy of Luxembourg, considering inhabitants to protect. The L_{den} replaces advantageously the old $L_{Aeq(6\text{-}22H)}$, and new software allows calculations of the exact L_{den} value of the most exposed façade of every inhabited dwelling.

A major concern is now about the delimitation of a single site: we are no more considering sites where complaints have been expressed and where limits have been fixed in a subjective way, whatever their length and location, but the whole length of the network on its both sides.

C. How to delimit a single site: elementary entities

We now face the same problem that the END introduced: what is the interest to have, as the END requests, *the estimated number of people living in dwellings that have their most exposed façade exposed to L_{den} in dB 4 m above the ground: 55-59, 60-64, 65-69, 70-74, > 75?* What can we do with those numbers given for a whole network, except compare different networks between them?

Now comes the evident need to get those figures for elementary entities, instead of the whole network, in such a way we definitively can compare sites between themselves in order to establish priorities, the original objective of the *ECU*. The idea is to define elementary sectors of the same length all along the roads / tracks: 500 m sectors were considered first, but starting the location of a 500 m sector does not fit any acoustic consideration and those sectors could not always been perfectly located to objectively represent an inhabited area; then, 100 m sectors have been considered being more representative: shorter sectors could lead to problems with curved axis, so 100 m is kept.

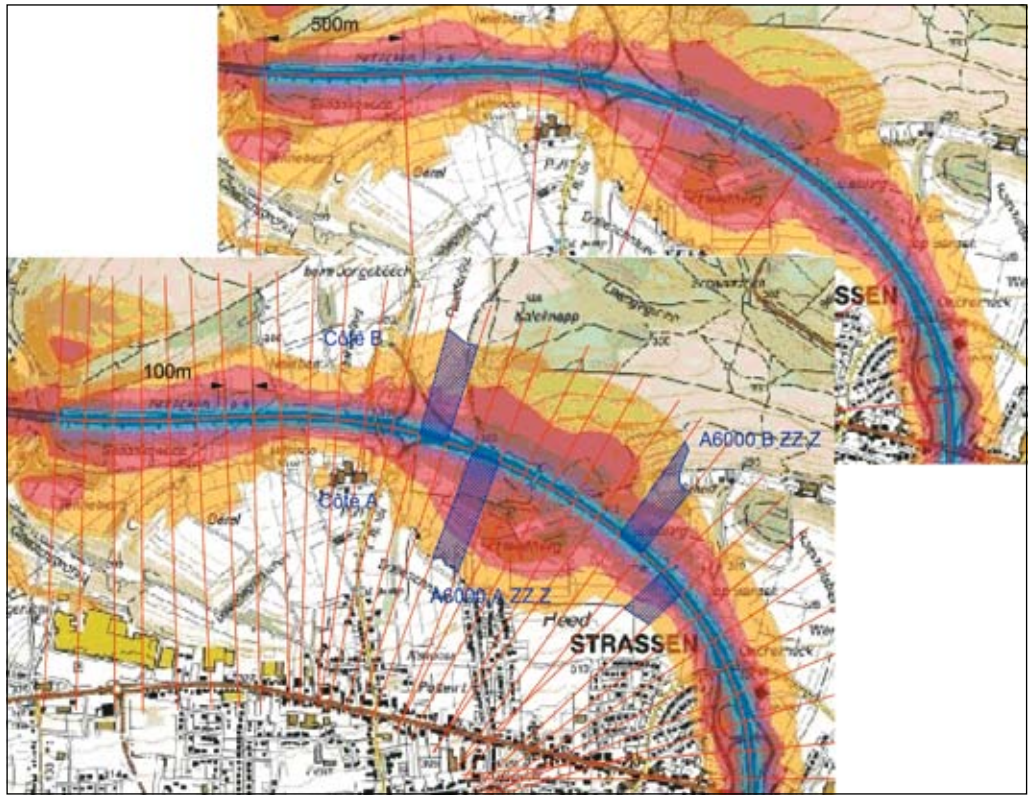

Figure 1: Definition of the elementary entities (500 and 100m) within which the ECU_{den} have to be calculated.

The figure 1 shows the definition and comparison between 500 m and 100 m sectors: the 100 m, or hectometric, sectors are delimited by: the 100 m sections of the infrastructure, the 2 normal lines at their ends, and the contour L_{den} = 55 dB(A). One can also understand the possible conflicts between sectors shorter than 100 m with curved infrastructures: the possible intersections between the normal lines should fall outside the contour L_{den} = 55 dB(A).

D. Assembling successive sectors into "urban entities"

For drafting noise action plans, sectors are maybe systematic and elementary but do not correspond to agglomerated inhabited areas: the administrations did ask to reassemble successive sectors in the most logical way in order to finally prioritize "urban entities" instead

		Nombre d'habitants par zone de bruit								
	site	55 - 60	60 - 65	65 - 70	70 - 75	75 - 80	80 - 85	>=85.0	Total	UCE_{den}	
	LXESC_A_00.28										
	LXESC_A_00.29										
	LXESC_A_00.30	16.4							16.4	67.6	
	LXESC_A_00.31										
	LXESC_A_00.32										
	LXESC_A_00.33										
	LXESC_A_00.34										
	LXESC_A_00.39										
	LXESC_A_00.40										
	LXESC_A_00.41										
	LXESC_A_00.42										
	LXESC_A_00.43										
	LXESC_A_00.44										
	LXESC_A_00.45										
Site 3 Fontaine Nord Est	LXESC_A_00.46	17.9							17.9	70.8	73.64
	LXESC_A_00.47	9.7							9.7	67.5	
	LXESC_A_00.48	12.7							12.7	67.4	
	LXESC_A_00.49										
	LXESC_A_00.50										
	LXESC_A_00.51										
Site 4 Fontaine Sud Est	LXESC_A_00.52	2.2							2.2	59.6	78.99
	LXESC_A_00.53	19.7							19.7	70.0	
	LXESC_A_00.54	20.9	12.2	4.6					37.7	78.2	
	LXESC_A_00.55										
	LXESC_A_00.56										
	LXESC_A_00.57										
	LXESC_A_00.58										
	LXESC_A_00.59										
	LXESC_A_00.60										
	LXESC_A_00.61										
	LXESC_A_00.66										
	LXESC_A_00.67										
	LXESC_A_00.68										
	LXESC_A_00.69										
	LXESC_A_00.70										
	LXESC_A_00.71										
	LXESC_A_00.72										
Site 6 Berchem Bivange Est	LXESC_A_00.73		10.4	18.4	2.9				31.7	82.4	93.32
	LXESC_A_00.74	4.6	5.0	2.3					11.9	74.3	
	LXESC_A_00.75	2.8			7.2				10.1	80.1	
	LXESC_A_00.76	35.7	0.6	5.6	8.0				49.9	82.3	
	LXESC_A_00.77	7.1	28.4	0.2	14.5				50.2	86.5	
	LXESC_A_00.78	21.8	11.4						33.3	75.1	
	LXESC_A_00.79			18.3					18.3	78.7	
	LXESC_A_00.80	4.9		9.8	23.7				38.4	86.5	
	LXESC_A_00.81	4.9	13.2		3.3				21.4	78.4	
	LXESC_A_00.82	21.2	13.3		9.3				43.9	83.5	
	LXESC_A_00.83	15.1	6.1	2.3	3.2	3.5			30.2	83.2	
	LXESC_A_00.84	7.5	6.2						13.6	71.3	
	LXESC_A_00.85				10.4				10.4	81.0	
	LXESC_A_00.86				1.5				1.5	75.9	
	LXESC_A_00.87										
	LXESC_A_00.88										

Table 1: UCE_{den} for 100 m sectors and grouping in "urban entities" for a railway line.

of sectors: this is not difficult while having the 100 m sectors, but could correspond to an important work considering the lengths of the considered networks (1.060 km of highways and 132 km of railways in the Walloon region; 129 km of highways and 23 km of railways in the Grand Duchy of Luxembourg).

In the Grand Duchy of Luxembourg, one has considered the table forms of ECU_{den} in order to define the "urban entities", as shown in table 1 and figure 2.

In this example, sector A30 (A is for the left side) has few inhabitants exposed to low L_{den}, while the grouping of sites 3, 4 and 6 is evident: their corresponding UCE_{den} is indicated at the rightest column.

In the Walloon region, due to the huge length of the road network, one has preferred to consider a graphic representation of the successive ECU_{den} in order to define the "urban entities", as shown in figure 3.

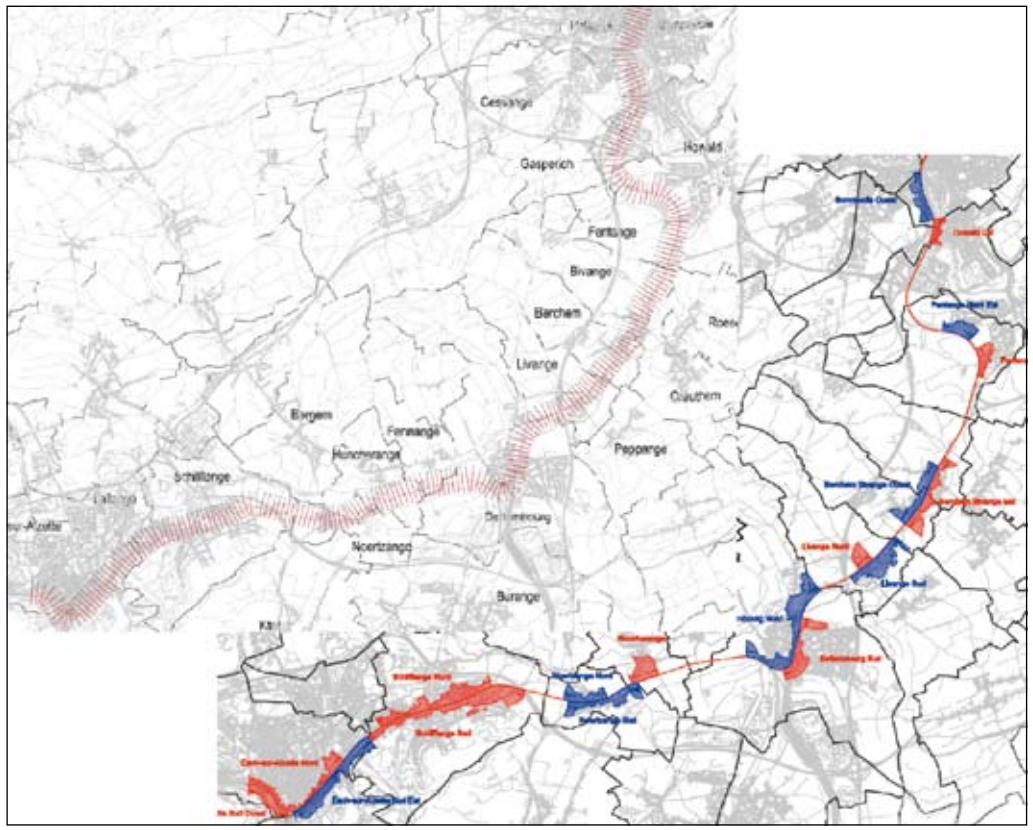

Figure 2: Location of the elementary 100 m sectors and grouping in "urban entities" for a railway line.

Figure 3: Using "sticks" to regroup successive elementary sectors toward "urban entities".

D. The new lists and strategy

Now that the "urban entities" have been located, we are now able to calculate the ECU_{den} inside every entity (on both sides of the infrastructure); we also calculate the $Max\ L_{den}$ and the $Max\ L_{night}$ of every entity.

In fact, if only ECU_{den} is used to prioritize "urban entities" between them, one could forget some "urban entities" where few dwellings / inhabitants are exposed, while they still could be highly exposed: $Max\ L_{den}$ and $Max\ L_{night}$ are kept for this reason.

The strategy adopted by the Walloon region and the Grand Duchy of Luxembourg is similar (apart counting the dwellings or the inhabitants), 4 lists are established:

List 1: regrouping all "urban entities" with $Max\ L_{den} \geq 70$ dB(A)
List 2: regrouping all "urban entities" with $Max\ L_{den} < 70$ dB(A)
List 3: regrouping all "urban entities" with $Max\ L_{night} \geq 60$ dB(A)
List 4: regrouping all "urban entities" with $Max\ L_{night} < 60$ dB(A).

Every list is sorted by the descending corresponding ECU_{den}: in such a way, one consider first only those sectors where $Max\ L_{den} \geq 70$ dB(A) and / or $Max\ L_{night} \geq 60$ dB(A).

The final 4 lists of "urban entities" are straightforward to use: high $Max\ L_{den}$ and / or high $Max\ L_{night}$ with high ECU_{den} means highly exposed sites with many exposed dwellings / inhabitants, what requires strong actions, probably along the infrastructure itself. High $Max\ L_{den}$ and / or high $Max\ L_{night}$ with low ECU_{den} means highly exposed sites with few exposed dwellings / inhabitants, where reinforcing the façade airborne noise insulation could be most appropriate.

Low $Max\ L_{den}$ and / or low $Max\ L_{night}$ with high ECU_{den} means less exposed sites with many dwellings / inhabitants, what could require actions but with less priority, and low $Max\ L_{den}$ and / or low $Max\ L_{night}$ with low ECU_{den} means less exposed sites with few dwellings / inhabitants, where actions are not the priority at the present situation.

Conclusions

In order to reply to the END action plans with an appropriate strategy, one needed to define solid and objective tools taking the exposure to ground transport noise into account.

The method presented here discriminate the exposure to noise in different elementary sectors of 100 m all along the concerned networks: $Max\ L_{den}$, $Max\ L_{night}$, and the ECU_{den} are systematically calculated for all the 100 m sectors on both sides of the concerned roads / railways, then 4 lists are drafted ($Max\ L_{den} \geq 70$, $Max\ L_{den} < 70$, $Max\ L_{night} \geq 60$, $L_{night} < 60$ dB(A)), in such a way that the most exposed dwellings / inhabitants are always taken into consideration, even if they are not numerous. In those 4 lists, the prioritization is done by sorting on the ECU_{den}. Successive sectors are regrouped in "urban entities" in the most logical way.

The method is objective: it takes the L_{den} and L_{night} into account, as well as the amount of dwelling / inhabitants and the L_{den} to which they are exposed (through ECU_{den}) and prioritize the exposed "urban entities" following the most logic strategy to explain to the concerned parties, including implicit cost-benefit considerations.

Acknowledgments

We gratefully acknowledge: the "Service Public de Wallonie" which regroups the administrations of the road network, the mobility (railways) and the environment, as well as the Ministry of Environment of the Grand Duchy of Luxembourg, the CFL (Chemins de Fer Luxembougeois) , and the administration of the "Ponts & Chaussées" (roads).

References

[1] Jean-Pierre Clairbois, Peter Houtave, David Meganck and Alain Thibert, "Prioritizing road noise protections" Proceedings Inter-Noise 2002, Dearborn, MI,USA (2002).

[2] "DIRECTIVE 2002/49/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 June 2002, relating to the assessment and management of environmental noise", (2002)

[3] "Practitioner Handbook for Local Noise Action Plans" - Recommendations from the SILENCE project http://www.silence-ip.org/. (2008).