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# AN INDICATOR FOR ROAD TRAFFIC NOISE: MONITORING AND PREDICTION MODEL

**L. Dekoninck*, D. Botteldooren*, G. Vindevogel**, R. Geens****

* The Ghent University (INTEC), St-Pietersnieuwsstraat 41, B-9000, Ghent, Belgium

** Administratie Milieu-, Natuur-, Land- en Waterbeheer (AMINAL), Graaf de Ferrarisgebouw Koning Albert II-laan 20 bus 8, B-1000, Brussels, Belgium

Tel.: 00 32 9 2673595 / Fax: 00 32 9 2673599 / Email: luc.dekoninck@intec.rug.ac.be

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## ABSTRACT
In this paper a pressure indicator for road traffic noise is discussed and a prediction model for the indicator is presented. The indicator is defined as the annual sound emission at a particular point near a major Flemish highway. When measuring this indicator one must be very careful to take into account weather effects and possible changes in road surface accurately. This is particularly important since the expected annual change in the indicator is very small. When modeling the indicator the evolution of car noise emission must be taken into account. This requires the type of cars and trucks and their age and relative density to be known. In this work the influence of product noise regulations is included in the model for the control period 1992-1998. Results are in good agreement with noise measurements. This increases the confidence in the model for predicting future evolution. Several future-scenario's (business as usual, sustainable) are presented in the paper.

## 1 - INTRODUCTION
Reporting on the state of the environment is usually done by tracing a well-chosen set of indicators. In general an indicator should be easy to understand, easy to follow-up and be relevant to monitor a policy issue. In this paper a pressure indicator for road traffic noise is discussed: the annual sound emission at a particular point near a Flemish highway. The emission is extracted from continuous noise immission measurements at 200 m from the highway which are part of a Belgian noise monitoring initiative (Automatic Network Noise Environment − ANNE) that started in 1992 [1]. The indicator can be regarded as representative for noise emission by highway traffic in the whole region since cars and trucks tend to move around quite freely in the area. However, one must be careful to eliminate site specific effects and seasonal fluctuations in emission and sound propagation. A first part of this paper concerns these required corrections (mainly due to weather conditions). The indicator is used in the annual Flemish environmental reports [2].
Environmental policy not only requires adequate monitoring, but also prediction for various scenarios. In order to predict future evolution for this indicator a model was created. The model takes in account the evolution of traffic density, the evolution of the fleet of vehicles in Belgium, European noise emission regulation for motor vehicles, tire noise, changes in the pavement, vehicle speed, speed distribution and congestion of the traffic. A few variables are not well known and need better quantification in the future.

## 2 - FROM NOISE IMMISSION DATA TO AN EMISSION INDICATOR
Immission measurements have to be corrected for site specific traffic density, effect on emission and propagation and for weather influences to make them representative for the whole region. Averaging out of weather effects over subsequent years can not be counted upon because noise measurements are not continuous due to elimination of periods with heavy wind or rain and due to equipment malfunction. $L_{Aeq(6-22)}$ was used to calculate the annual average immission. Only working days were taken into account. These choices are mainly inspired by the available traffic density measurements. Without any

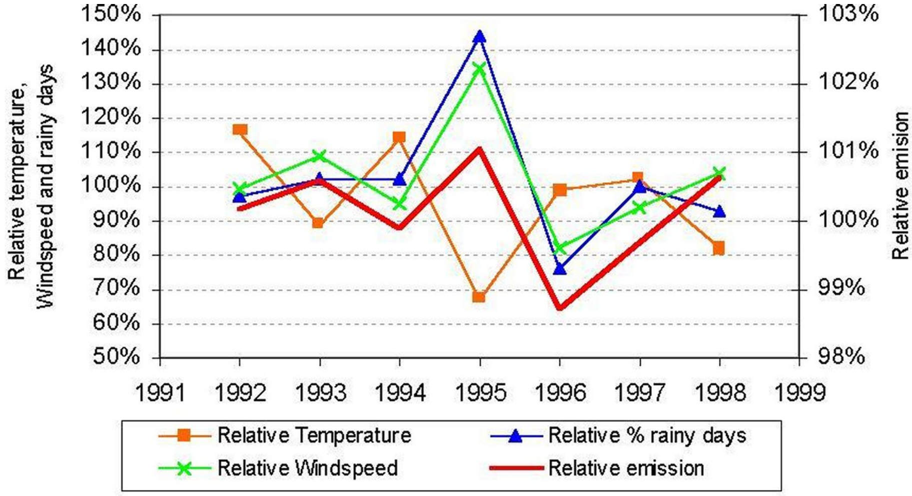


**Figure 1:** Relative annual noise emission versus relative temperature, wind velocity, and number of rainy days.

of the above mentioned corrections yearly averages show strong fluctuation (figure 1). As shown in Figure 1 the most important meteorological parameters reflect the same (wind velocity and precipitation) or the inverse (temperature) trend as the indicator (relative annual noise emission).

Possible influences on the measured immission can be classified into three separate groups: changes in traffic (density, speed, share of heavy vehicles), external effects on the source (precipitation, temperature of the pavement) and the propagation (wind direction, temperature and wind gradients). For each of these effects independent sources of information were consulted followed by an analyses of the data at hand. Well-defined subsets of the data are used to extract trends for different meteorological and seasonal effects to make sure that the same effect is not included several times. As an indication of the quality of the resulting correction, monthly averaged noise immission is investigated. It is assumed that a good correction for meteorological effects should lead to a monthly fluctuation proportional to the logarithm of the traffic density. There is no information about monthly fluctuation in amount of heavy vehicles and average velocity of the traffic. Therefor the amount of heavy vehicles is assumed to be constant. To reduce the influence of monthly changes in average traffic velocity, extreme weather conditions that could affect the velocity are removed (strong rain, fog, and temperature below zero).

*Precipitation*: A wet road surface increases rolling noise. No such trend was found in the data. This can be due to the poor detail on rainfall (liter per day) but a lot of precipitation also changes traffic velocity drastically, which counteracts the expected higher emission. No correction was introduced. Days with precipitation over 10 liter a day were removed.

*Temperature*: In several papers the effect of the temperature of the pavement on measured sound pressure near the road was reported (about -1 dB(A)/10°C) [4]. A subset of the data (no weekend, no precipitation, low wind velocity, only downwind conditions) showed exactly the trend found in literature [4]. It is not clear however if this is indeed caused by a change in noise emission or by an increased upward bending temperature gradient. Both correlate with daily averaged air temperature, which is the parameter used in this analyses. The effect of a correction for temperature on the seasonal fluctuation is shown in Figure 2. The effect on the annual averages is shown in Figure 3.

*Wind directions and velocity*: Wind is a major factor. Both upward refraction and annulation of upward refraction due to temperature gradient can occur. It should be remarked that measurements were made at a short distance from a line source so the angle of influence can be relatively large. A combined analyses for wind direction and wind velocity was done and a correction was based on it. The effect on the monthly fluctuation is shown in Figure 2. The resulting curve lies very close to the logarithm of the traffic density. These corrections are used to calculate the evolution of the indicator, shown in Figure 3.

*Changes in the pavement*: The type of pavement did not change over the observation period. Four of the six lanes have been renewed in spring 1993.

## 3 - PREDICTION MODEL

An increase in noise emission can be expected due to the increasing number of vehicles. The number of vehicles passing by during the day (6h − 22h), was measured at two locations near the noise mea-

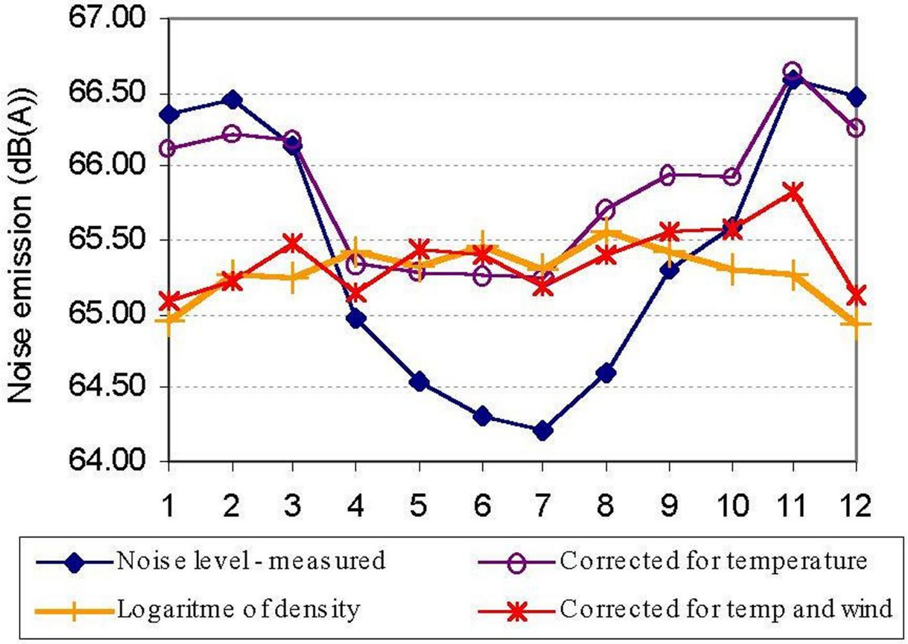


**Figure 2:** Monthly fluctuation of noise emission indicator with and without corrections and logarithm of traffic density.

surement point [5] and is specific for the measurement site. Prediction until 2010 was retrieved from the environmental report MIRA-S 2000 [6] of the Flemish government and is representative for all highways. A simulation that only includes the volume increase is show in figure 4 (label 'autonomous'). In this simulation it is also assumed that traffic speed remains constant. The increase found in this simulation does not reflect the trend seen in the measured indicator between 1992 and 1998. The effect of the increase in traffic density is compensated to some extend by lower noise emission of individual vehicles. This may be caused by quieter technology or lower average speed.

To model the reduction of noise emission by the use of quieter technology the influence of European community noise emission regulation for motor vehicles is estimated. The effect of the implementation of these regulations shows some latency due to the slow replacement of old vehicles. It is assumed that the Belgian fleet is representative for the vehicles passing by the measurement point. The evolution of the production year and engine power was taken from the environmental report MIRA-S 2000 [6]. It is also well known that the European noise emission regulations do not concentrate on tire/pavement noise, which results in little effect on the vehicle noise emission in drive by conditions. In literature the effect of the emission regulations at highway speed is shown to be small, sometimes even negligible [4], [7]. Here it is assumed that there is some emission reduction due to technology. This could be a direct result of the regulations or an indirect result of lowering interior noise which is a big concern to the constructors. Finally all cars and trucks do not drive at the allowed speed (120km/h for cars; 90km/h for trucks). If a realistic speed distribution is used, a small reduction of average noise emission of highway traffic is found for each step in the EC-emission limits. Based on these considerations, an average reduction of 1 dB for cars and 2 dB for heavy vehicles is assumed. This results in the simulation labeled 'Business as usual (BAU)' in figure 4. The result explains the measured indicator between 1992 and 1998. With these assumptions a small decrease in noise emission can be expected during the first few coming years, but a period of increasing noise emission by highway traffic noise may follow.

At the time this paper was written, it was not possible with the available data to distinguish between quieter technology and lower driving speed as a cause for the lower noise emission. It could be a combination of the described effects. Two conclusions can be made. First, there has to be a reduction of noise levels to explain the measurements. Second, future regulations should focus more on tire noise to prevent a future increase in highway noise.

A "Sustainable development" scenario was also evaluated (figure 4). The drop in estimated noise levels is a primary result of restricting the growth of traffic, combined with a drastic reduction of heavy vehicles on the highways. The slope continues after 2005 because of a lower number of heavy vehicles.

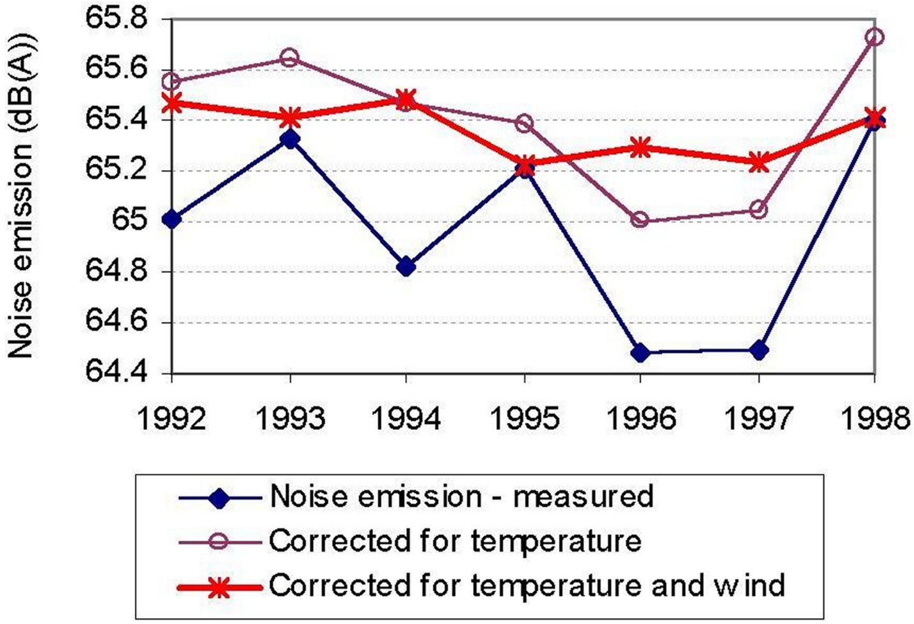


**Figure 3:** Noise emission indicator with and without corrections.

**4 - CONCLUSION**

An indicator for highway noise emission was defined. It was explained how different effect must be taken into account to translate immission measurements at a distance of 200m to the emission indicator. The indicator does not show the increasing trend expected on the bases of increasing traffic density. There has to be an effect to counteract the growing traffic density. There are several candidates, more or less correlated with noise emission regulations. They were included in a simulation that also allows to predict future evolution.

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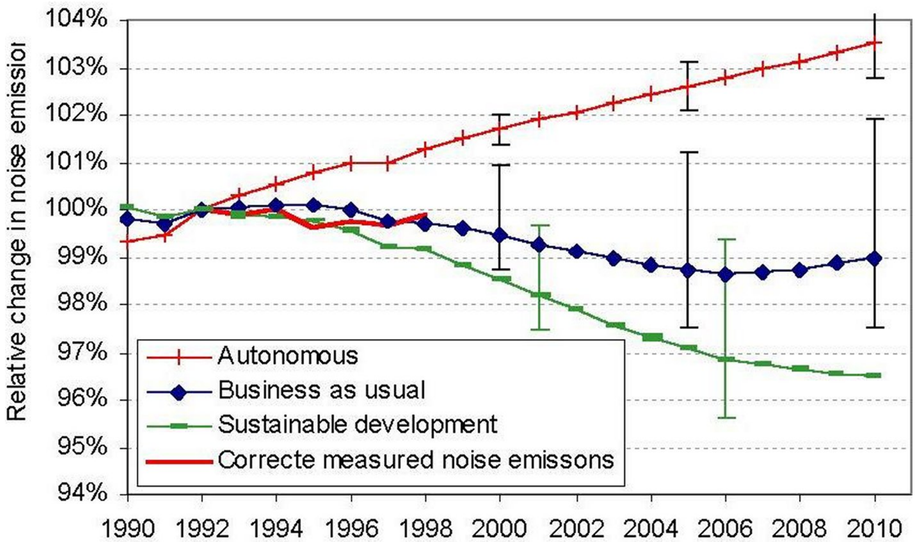


**Figure 4:** Simulations of the evolution of the indicator including error estimates on the predictions.