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A Common European Calculation Standard for Traffic Noise Utopia or Reality?

Hans J.A. van Leeuwen
dgmr consulting engineers b.v.

P.O. box 82223
2508 EE, The Hague
The Netherlands
Telephone: +31 70 350 3999
Fax: +31 70 358 4752
E-mail: LN@DGMR.NL

Douglas Manvell, MIOA
Brüel & Kjær A/S

Skodsborgvej 307
2850 Nærum
Denmark
Telephone: +45 45 800 500
Fax: +45 45 806 209
E-mail: DMANVELL@BK.DK

Abstract
The European Commission's Green Paper on Future Noise Policy has led to debate about harmonisation of noise standards. National calculation standards exist in several countries and give a large variety in results. In addition, the accuracy and applicability of the new ISO 9613 standard is under debate.

What are the advantages of a common standard? What quantities do we want to calculate? Which ones are relevant and which can actually be calculated? Should we calculate the noise propagation using empirical methods, or do we need more advanced techniques? Finally, a detailed acoustic description of the source is essential.

This paper will describe the quantities which are relevant and can be calculated. It will also propose a general method for the calculation of traffic noise.

1. Introduction

Harmonisation of noise standards in Europe is the only way to form a policy against noise annoyance. To compare the acoustic situation at two locations, for example Athens and Glasgow, it is necessary to calculate a dB(A)-level that is representative of these locations. When these dB(A) values are not representative it is like comparing apples and oranges.

From reading various papers written by Pompoli [1,2], Witte[3], van den Berg & Gerritsen [4], van Leeuwen [5,6,7] and Verbandt [8] it is clear that there is a very large variation of calculation results. The reason for this is mostly due to the definition of the noise source, the amount of calculations made and the variation of weather effects. In other words one should ask: "What do I want to calculate?"

2. A common standard

The advantages of a common standard should be clear. The only way to make a European policy against environmental pollution is to have a uniform way to determine the quantity of annoyance. Technical and scientific discussions about the accuracy and validity of calculation models will only lead towards an unclear policy, or even no policy at all. The quantity of annoyance is not related to the discussion of the reliability of a single dB(A) figure. It is important that a typical situation can be qualified in a representative way. Additionally, the way of quantifying must be reproducible. Calculations made by several institutes, consultants and authorities, must lead to the same results and conclusions.

A common standard can lead to a discussion on whether the road traffic in Glasgow is noisier than in Athens. Today, most of the discussion would cover the fact that the measurement or prediction methods used are not the same - apples and oranges. These comments divert the discussion away from the real problem which might be the differences in traffic flow, the types of road surface or the level of maintenance of the vehicles. When using calculations to determine the traffic noise, a large range of calculation results from several different computer models only contributes to this negative aspect of the discussion. Only significant facts will help quieten the world for a higher quality of life. (The theme of InterNoise 1997).

3. The annoyance of noise in the environment

Annoyance due to the noise of a road or a railway is directly related to the amount of dB(A)s that will load the facade of a dwelling. This means that if you open a window of the house, you calculate the amount of sound intensity (acoustical energy per square metre) which enters the room.

Most of the prediction models for both road and rail traffic calculate the equivalent sound level during one or several hours of the 24 hour day. The CRTN [19] model from the UK is the only one that calculates the L_{10}-level but, in principle, the calculation background is similar. The calculations are made based on an average of the traffic flow. Most of the calculations are based on the annual average weekday traffic. For road traffic, the calculations are based on average noise emissions of a normal passenger-car and of light and heavy trucks. There is also an average of the type of road surface at that particular place, and an assumption that the road surface is in normal condition. The speed of the traffic is mostly based on the representative speed on that particular road or railway - usually the permitted maximum speed.

The propagation of the noise is also based on an average. It is, for example, not practical to measure the acoustical impedances of a brickstone road, grassland, a cornfield, a lawn, etc. The acoustical impedance of reflecting objects and reflecting facades should be also known. Another very important factor is the meteorological influence (i.e. wind, temperature and humidity). The influence of wind is illustrated in Figure 1. Some prediction models will always calculate the downwind situation. Others will calculate the average weather situation.

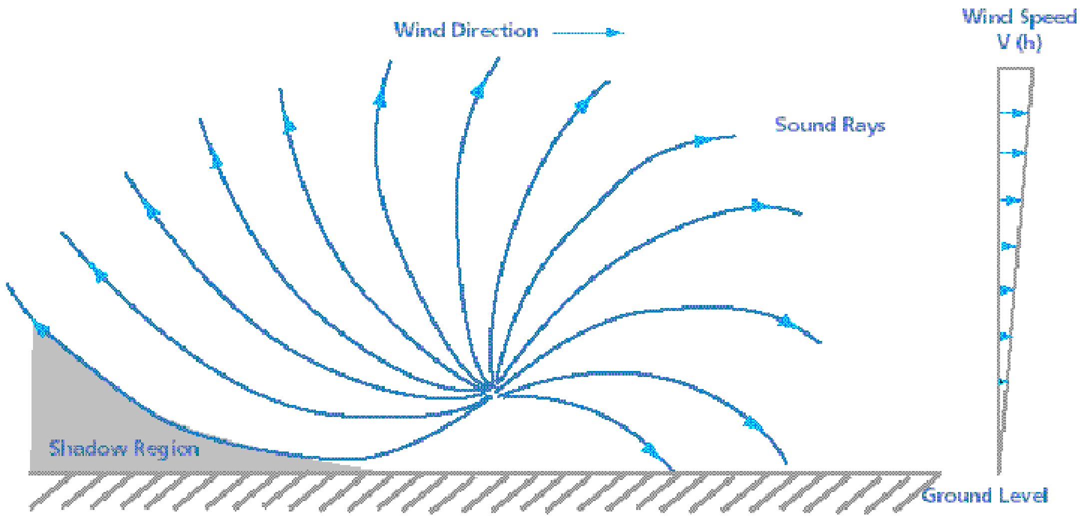

Figure 1. The influence of wind speed, wind direction, shadow region, sound rays on the noise propagation.

To summarise, it must be said that a prediction model will always calculate the equivalent sound level of an average situation, which is representative of the situation and which is reproducible (compared to a model where you can calculate the sound level of one particular car, one particular tyre, one particular road surface, some well-defined ground surface and facades, and one particular weather situation). This latter method of calculation can be likened to the laboratory, or engineering, method of measurement. Prediction models must be seen as a survey method. Prediction models use empirical formulas. For an engineering method we need more advanced techniques like boundary elements or parabolic equations. That is outside the scope of this paper.

4. Prediction models

Generally it has to be noted that, in principle, a prediction model is not computer software. A prediction model is mainly described on paper and laid down by law, standard, norm or guideline. Computer software is always an interpretation of this paper document.

The prediction of the sound level at a receiver point has to be divided into the following two aspects:

- ☑ The first aspect is the description of a vehicle as a noise generating phenomena that may be described as a combination of different noise sources. Each source has a sound power level and has to be given a position and a height location. In addition, the relationship between the speed and other emission-relevant qualities, such as a different road surface or track structure, has to be described. Of course, the description of the sources will be dependent on the type of car, truck or train. Some national models also incorporate the effects of social habits on the traffic flow.
- ☑ Acoustic propagation models will be (or are supposed to be) very general. A propagation model gives a description of the attenuation of noise from source to recipient. In the end the noise of a vehicle will not propagate in a different way to any other kind of noise. A single vehicle is basically a moving point source. The equivalent sound emission of a road, or railroad is a line source which can be divided into a large number of point sources. The international standard ISO 9613 Attenuation of

sound during propagation outdoors [14,15] is based on a point source model, but there are also different models like the German VDI 2714/2720 [9,10], the Austrian ÖAL 28 [12], the Dutch road traffic model SRMII [22], the Dutch industrial noise model (IL-HR-13-01 C8) [13], and the road traffic noise model CRTN [19] from the UK.

In Figure 2 the general set-up for a prediction model is indicated. It is clear that there are separate factors that influence the noise source and factors that influence the acoustic propagation.

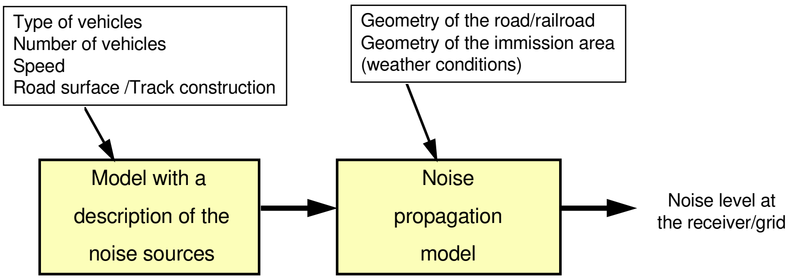

Figure 2 The general set up of a prediction model

Noise sources

The description of the noise source concerns the position of the source and the related sound power level. For road traffic, the dominant sources are the radiated acoustic energy of the tyre and the noise produced by the effect of air-pumping. For trains, the dominant source is the radiated acoustic energy of the wheel, with bogie and the rail, in contact with the track structure. Other noise sources are the exhaust, other equipment and noise due to aerodynamic sources. Trains running at speeds above 250 km/h have significant aerodynamic sources.

It is essential to determine the sound power levels of the different distinguishable noise sources. The physical height of a noise source above the road or track and above ground level is essential for determining the acoustic propagation from source to receiver. A higher noise source, for example, will have less attenuation due to the acoustic absorption of the ground. While erecting a noise barrier, the higher noise sources will not be screened, or screened less, than lower noise sources.

An example of the positioning of the noise sources of a high speed train is shown in Figure 3. The position of the sources and the spound power is determined by measurements.

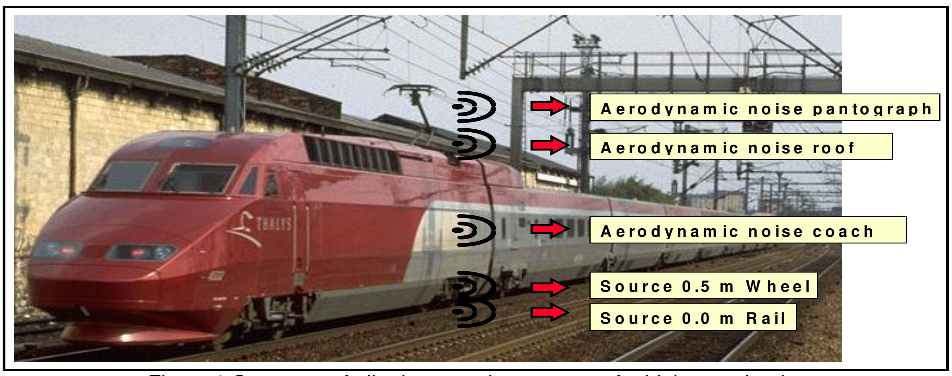

Figure 3 Summary of all relevant noise sources of a high speed train.

The main principle of predicting noise in the environment (survey method)

In order to calculate a sound level at a certain point due to a known noise source, one can use a model for acoustic propagation in the free field. This general principle to predict a sound level is based on empirical estimations.

In order to be able to make the total calculation the following formula can be used:

$$L_{eq} = E - A_{div} - A_{atm} - A_{gr} - A_{bar} - A_{misc} + C_{refl} - C_{meteo} \quad \text{in dB or dB(A)}$$

where

L_{eq}	the equivalent sound pressure level at a receiver point
E	the sound emission of a noise source defined in the source model
A_{div}	the attenuation due to geometric spreading of the noise
A_{atm}	the attenuation due to atmospheric absorption
A_{gr}	the attenuation due to the absorption of the ground
A_{bar}	the attenuation due to a barrier or another obstacle
A_{misc}	the miscellaneous attenuation (foliage, industrial sites, housing, ...)
C_{refl}	a correction for the contribution caused by reflections of noise
C_{meteo}	a correction for meteorological effects

The description of the propagation of sound from source to receiver is described in various propagation models. These models also describe the various ways to calculate the attenuation and correction terms. The calculation can be made directly in dB(A) or per octave frequency band.

5. Development of a common standard

Future development of a common standard for the calculation and prediction of road traffic and rail traffic noise must be seen from a technical point of view and from a political point of view.

The technical point of view

The implementation of a complete new prediction model that might be accepted throughout Europe is utopic. There will always be a discussion regarding various parts of this model. These discussions will lead to a delay of the application of the new model. A "nice" example of such discussions is the implementation of one European plug for electrical equipment. Almost every country has its own ideas resulting in our continued need for adapters.

In the realistic world of prediction models, we must hook on to the ISO 9613 standard concerning a general noise propagation model. This standard has been heavily criticised but it is the only standard above the level of national standards. A future revision of this standard (possibly within the framework of “EN”) will result in a general revision of the calculation of noise propagation with the consequence that all calculation results at the receiver points will remain comparable.

The development of a general description of the source will produce much discussion as there is no international standard for it. Therefore, we propose, as a first step, the establishing of national source description models based on information of the national prediction models. A great deal of effort was involved in developing and refining these national prediction models. This very valuable information (which also acts as a useful reference) must not be lost with the introduction of a common European standard. In addition, national standards are also based on local measurement techniques, definitions and other socio-demographic factors such as the age and mix of transport pool, infrastructure and their maintenance.

National source description models should be developed for use with the propagation model described in the existing ISO 9613. They should also be adaptable to new developments and for the possible incorporation of information from other countries. In other words, the source description model must be flexible. The ISO 9613 standard should be the basis for the propagation model as it covers purely physical phenomena common across Europe.

The political point of view

It is important that a rough picture is made of the environmental pollution due to noise throughout Europe. To speed up the process, this should be done in a very simple way. The method could be simpler than the method described above, for example, taking only into account the distance of the receiver from the traffic and the traffic flow. This calculation should be pessimistic - in other words, always calculating higher levels. Then, for critical or interesting situations, it may be useful to make a more detailed calculation, for example, in the way described in this paper. Finally, in very critical situations, where this method might have reached its limits of application, it should be possible to proceed to more advanced techniques. So there must be a focus from a rough approach to a more comprehensive technique similar to what we see in standardised measurement techniques. With these more comprehensive techniques we have to realise that the results may not be directly comparable with those from the simple method. The more comprehensive methods predict noise levels more accurately making it possible to make predictions in more complex situations.

6. Conclusions

The advantages of a common standard are clear. The only way to make a European policy against environmental pollution is to have a uniform way of determining the quantity of annoyance. The way of quantifying noise annoyance must be reproducible. Calculations made by several institutes, consultants and authorities, must lead to the same results and conclusions. Only significant facts will help quieten the world for a higher quality of life.

Prediction models will always calculate the sound level of an average situation which is representative of the situation and which is reproducible. This is contrary to a model where you can calculate the sound level for a particular situation.

It has to be generally noted that, in principle, a prediction model is not computer software. A prediction model is described on paper and laid down in a law, standard, norm or guideline. Computer software is always an interpretation of this paper document. The prediction of the sound level at a receiver has to be divided in two aspects - the description of the noise sources and the propagation of sound from source to receiver.

The implementation of a completely new prediction model which might be accepted throughout Europe, is mere Utopia. Realistically, we must hook on to the ISO 9613 standard and establish flexible national source descriptions . To get a full picture of the noise pollution in Europe, it is important to start with a rough approach and proceed to more comprehensive techniques in selected situations.

7. References

[1] P. Fausti and R. Pompoli, Intercomparison of computer programs for traffic noise simulation. InterNoise '96

[2] R. Pompoli, a.o. Intercomparison of computer programs for traffic noise simulation. Atti del XXIII Congresso Nazionale, Bologna 1996

[3] R. Witte, Comparison of noise calculation models, EuroNoise 1995

[4] M. van den Berg, E. Gerritsen, Comparison of calculation models, InterNoise 96

[5] J.J.A. of Leeuwen. Noise prediction models to determine the effect of barriers alongside railway lines, Journal of Sound and Vibration (1996).

[6] J.J.A. van Leeuwen, D. Manvell and R. Nota, “Some prediction models for the calculation of traffic noise in the environment”, InterNoise 96 (page 3139).

[7] J.J.A. van Leeuwen and R. Nota some noise propagation models used for the prediction of traffic noise in the environment. InterNoise 1997

[8] F. Verbandt, Comerciele akoestische software ter voorspelling van geluidverlden buiten, Geluid nummer 3 1997 (in Dutch)
[9] Schall Ausbreitung im Freien (outdoor sound propagation). VDI 2714. Verein Deutscher Ingenieure. January 1988.
[10] Schallschutz durch Abschirmung im Freien (outdoor sound propagation). VDI 2720. Entwurf Februar 1991.
[11] ÖAL-Richtlinie nr 30 Berechnung der Schallimmission durch Schienenverkehr. 1993
[12] ÖAL-Richtlinie nr 28 Schallabstrahlung und Schallausbreitung. Österreichischer Arbeitsring für Lärmbekämpfung 1987.
[13] IL-HR-13-01, Handleiding meten en rekenen industrielawaai, Dutch Ministry of Environmental protection (VROM) 1981.
[14] ISO/DIS 9613-1: "Acoustics - Attenuation of sound during propagation outdoors - Part 1: Calculation of the absorption of sound by the atmosphere.", ISO, 1993.
[15] ISO/DIS 9613-2.2: "Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation.", ISO. 1996
[16] "Beräkningsmodell för Vägtrafikbuller - Del 1: Beräkningsmodell", Naturvårdsverket, 1989 (in Swedish).
[17] "Beräkningsmodell för Vägtrafikbuller - Del 2: Bakgrundsmeterial", Naturvårdsverket, 1989 (in Swedish).
[18] "Beregningsmodel for Vejtrafikstøj", Vejdirektoratet, 1991 (in Danish).
[19] "Calculation of Road Traffic Noise", Department of the environment and Welsh office, 1988.
[20] "Guide du Bruit des Transports Terrestres - prévision des niveaux sonores", Centre d'Etudes des Transports Urbains, 1980 (in French).
[21] "Richtlinien für den Lärmschutz an Straßen RLS-90.", Der Bundesminister für Verkehr, 1990 (in German).
[22] "Reken- en Meetvoorschrift Verkeerslawaai.", De minister van Volksgezondheid en Milieuhygiëne, L. Ginjaar, 1981 (in Dutch).
[23] LANG, J.; BRUNNER, P.: "Überarbeitung des Rechenverfahrens der RVS 3.114 Lärmschutz.", Bundesministerium für wirtschaftliche Angelegenheiten, Straßenforschung - heft 443, 1995 (in German).