# Adaptation of national noise prediction methods to Directive 2002/49/EC Requirements on Noise Mapping Tools

Dr.-Ing. K.-G. Krapf, Edgar Wetzel
Wölfel Meßsysteme·Software GmbH+Co.KG, D-97204 Höchberg, Max-Planck-Str. 15, Germany, **{krapf, wetzel}@woelfel.de**

Most EU Member States tend to use an adapted version of their national noise propagation calculation methods for strategic noise mapping, which leaves the recommended interim computation to those without national methods. Strategic noise mapping relies on Noise Mapping Software, which is able to manage large amounts of data and does comply with the Directive. In addition to national differences in handling traffic flow data for the assessment periods „day“, „evening“, „night“ and in the use of meteorological corrections to determine long-term levels $L_{den}$ and $L_{night}$ a further difference between Member States is in the estimation of the number of people exposed. In particular the interpretation of the „most exposed façade“ leads to significant differences. Requirements on Noise Mapping Software will be explained and different estimation techniques for the number of people exposed to noise will be presented. It will be shown that the strategy used to attribute inhabitants to façade noise levels depending on the available data has a major influence on the results and subsequently on the planning and decision-making process. Another undesired influence is Noise Mapping Software quality. Possibilities to control it will be briefly presented. The host country Hungary will serve as an example to illustrate the adaptation of national methods for road and railway traffic and industrial noise to the Directive and to show the impact of different approaches in estimating the number of people exposed to noise with emphasis on both the concept “most exposed façade” and data availability.

## 1 Introduction

The feasibility of producing a software code from the available English and German translations of the Hungarian calculation methods were checked against the requirements for noise mapping software published in the AR-INTERIM-CM report [7] and in two EC documents 2002/49/EC [1] and 2003/613/EC [2]. The close co-operation with national experts proved valuable in solving technical questions and to assure quality of the final software code.

The technical solutions described in this text have been developed and tested in the EU PHARE project “Strategic Noise Mapping in Hungary”.

## 2 Discussion

### 2.1 General information

The project deals with earth-bound sound sources (road traffic, railway traffic, industry) only.

The production of a software code from a calculation method text is a technical challenge that reveals weaknesses of the original text in terms of legibility, transferability into a technical solution and coherence. The basis for the assessment of the feasibility of producing a computer code were the German translations of the Hungarian calculation methods (Road Technical Rules Ut 2-1.302:2000 (traffic) [5], MSZ 07-2904:1990 (railways) [6] and MSZ 15036:2002 (propagation of sound)) specifically produced for this study. Furthermore an English text for submission to EC DG Environment with regard to the Hungarian calculation methods is available and has been consulted.

It must be noted that the sound propagation method used for all earth-bound sound sources is MSZ 15036:2002. Therefore, the sound propagation method and required adaptations are discussed in a single isolated section. These adaptations remain true for all earth-bound sound sources types, i.e. road traffic, railway traffic and industry. The major focus is then put on the connection between the noise emission models defined for the individual sound sources and the sound propagation method. The suitability of these methods to serve for the purpose of Strategic Noise Mapping according to Directive 2002/49/EC has been shown in a previous project phase [8].

### 2.2 Sound propagation for earth-bound noise sources

The sound propagation method for all source types is MSZ 15036:2002. In a previous report [8], it was shown that this method derives from VDI 2714 and ISO 9613-2. For a comparison of MSZ 15036:2002 with ISO 9613-2 and VDI 2714 refer to [8]. A detailed comparison showed that this method is identical to the EU interim computation method [1] for industrial noise ISO 9613-2 [9] using the alternative method of calculation of section 7.3.2 for both A-weighted overall levels and frequency band levels. According to page 14/25 of Progress Report A [8], “the meteorological correction […] C0 should be used for all earth-bound sources”.

ISO 9613-2 can be used for all source types that can be described by means of omni directional point sound sources. Using a distance criterion for dynamic segmentation of line sources into component point sources of type omni directional sound source, ISO 9613-2 can be used as propagation method for road and railway noise sources.

ISO 9613-2 can be programmed such as to handle higher-order reflections and makes them available for all connected source types.

EU Recommendations 2003/613/EC [2] specify the requirements for sound propagation methods with regards to the noise indicators $L_{den}$ and $L_{night}$, the receiver height above ground and meteorological correction. In summary these are:

- $L_{den}$ and $L_{night}$: The need for three rating periods day, evening and night equally defined for all sound sources and covering the full 24h-day. According to [2] the general equation that must be programmed in a software implementation of an outdoors sound propagation method suitable for the production of strategic noise maps is:

$$L_{den} = 10 \cdot \lg \frac{1}{24} \left( t_d \cdot 10_{L_{day}/10} + t_e \cdot 10_{(L_{evening}+5)/10} + t_n \cdot 10_{(L_{night}+10)/10} \right)$$

where:

— $t_e$ is the length of the shorter evening period, where $2 \le t_e \le 4$,

— $t_d$ is the resulting length of the daytime period,

— $t_n$ is the resulting length of the night-time period,

and

— $t_d + t_e + t_n = 24$ hours

Figure 1 – Adapted definition of Lden [2]

- Receiver height: The standard receiver height above ground is 4m+/-0.2m, but other receiver heights are allowed for specific applications.
- Meteorological correction: The meteorological correction used in the outdoors sound propagation method must b such that the resulting levels are long-term levels taking into account the average meteorological situation of the site (or simplified assumptions in case of lack of more precise data).

According to [2], the following specific adaptations to ISO 9613-2 are required to make the calculation method compatible with the requirements of 2002/49/EC [1]:

Table 1 – Adaptations of ISO 9613-2 according to 2.5.2 of [2]

| Subject | Result of comparison — action |
|---|---|
| Noise indicator | The definitions of the base indicators are identical: A-weighted long-term average sound level determined over a long period of time of several months or a year taking into account variations in both emission and propagation.<br>Assessment periods day, evening, night following Directive 2002/49/EC have to be introduced. |
| Propagation | |
| — atmospheric absorption | Data have to be chosen at national level in order to establish a table with air attenuation coefficient versus temperature and relative humidity typical for various European regions concerned, based on ISO 9613-1. |

ISO 9613-2 should be used as the propagation method for all ground-bound noise sources. This recommendation is based on the following facts:

- By definition, all Hungarian calculation methods for earth-bound sound sources rely on MSZ 15036:2002 for propagation outdoors.
- There is a close tie between MSZ 15036:2002 and ISO 9613-2.
- ISO 9613-2 is referenced in 2002/49/EC [1] as the interim computation method for industrial noise and a description of the required adaptations is readily available in EC Recommendations 2003/613/EC [2].

## 2.3 Hungarian emission calculation for earth-bound sound sources

The noise emission level of a point sound source in ISO 9613-2 is the sound power level $L_w$. For line sources a sound power level $L_{w'}$ relative to unit length (i.e. relative to 1m line length) is required. However, the Hungarian calculation methods for road and railway traffic define the emission level as a sound pressure levels at either 7.5 or 25 distance from the road. There is thus a need for a transformation of these levels into $L_{w'}$. This transformation is explained in the following chapters for to the two noise emission models for road and railway noise sources.

For a sound pressure level at a distance of 25m the mathematical transformation into a sound power level relative to unit length $L_{w'}$ has been developed using the approach described in [3] as follows:

$L_{Aeq(25)}$ is the sound level applied to a reference distance of 25m.

(1) $L_{w'} = E + 20$ dB => $E = L_{w'} - 20$ dB

(2) $L_{eq}(1) = E + 12 = L_{w'} - 8$ dB

With:

$L_{eq}(1) = L_{eq}(25) + 10 \log (25/1) = L_{eq}(25) + 14$ dB

Equation (2) gives

$L_{eq}(25) + 14 \text{ dB} = L_{w'} - 8$ dB

⇨ $L_{w'} = L_{Aeq}(25) + 22$ dB

The development of an equation for the transformation of a sound pressure level at 7.5 m distance can be obtained by analogy.

### 2.3.1 Road traffic noise

- Road traffic noise is described in both [4] pages 2 to 6 and ANNEX-A and [5]. The information concentrates on the determination of sound emission levels for the typical Hungarian car fleet.
- The noise emission part has been designed to cope with the typical Hungarian traffic fleet composition and the frequentation of roads of different types.
- The noise emission model includes corrections for speed, traffic flow, road gradient, and road surface. ([4], ANNEX-A, p.21).
- The noise emission is determined at 7.5 m distance.

A fundamental problem in the connection of the Hungarian road traffic noise emission model to the propagation method ISO 9613-2 is the calculation of $L_{w'}$ (i.e. a sound power level relative to unit length) from a given emission level $L_{Aeq}(7.5)$. The Hungarian emission method calculates a sound emission level for roads at 7.5m from the road. On the basis of the theoretical development shown above, the corresponding equation for road traffic noise is:

$$L_{w'} = L_{Aeq}(7.5) + 10*\log(7.5/25) + 20 \text{ dB} = L_{Aeq}(7.5) + 14.8 \text{ dB}$$

Further to technical tests of the Hungarian expert led to a need to apply a correction to the theoretical relationship due to the incoherent character of the sound source leading to the following final equation:

$$L_{w'} = L_{Aeq}(7.5) + 12.5*\log(7.5/25) + 20 \text{ dB} = L_{Aeq}(7.5) + 13.5 \text{ dB}$$

For each of the three rating periods day, evening and night a separate $L_{w'}$ must be calculated.

### 2.3.2 Railway noise

- Railway noise is described in both [4] pages 6 to 8 and ANNEX-B and [6]. The information concentrates on the determination of sound emission levels for the typical Hungarian rolling stock.
- The noise emission part has been designed to cope with the typical Hungarian rolling stock on typical Hungarian tracks.
- Trains are grouped into four categories.
- The noise emission model includes corrections for speed, type of track, braking, and crossings/bridges/curves etc. ([4], p.7). The information provided in ANNEX-B is rather rough.
- The noise emission is determined at 25 m distance.

In MSZ 07-2904:1990 (railways) a sound level $L_{Aeq(25)}$ is calculated from the parameters A, B, Q, l, v, p, Kp and Kk.

$L_{Aeq(25)}$ is the sound emission level at a reference distance of 25m. The theoretical development of the transformation has been shown in the above. Following Hungarian expert input the difference between $L_{eq}(1)$ and $L_{w'}$ for incoherent sound sources is 6 dB. Accordingly, the equation for the Hungarian calculation method for railway noise is:

$$(3)\ L_{w'} = L_{Aeq}(25) + 20 \text{ dB}$$

For each of the three rating periods day, evening and night a separate $L_{w'}$ must be calculated.

## 3 Conclusions

QA of the technical approach described in the above has been ensured and documented in the EU Phare Project “Strategic Noise Mapping in Hungary”.

The study revealed and described the technical prerequisites for the production of a computer-based implementation of the Hungarian calculation methods for earth-bound sound sources with emphasise on identifying inconsistencies and providing technically viable solution.

## Acknowledgements

The authors would like to thank Mr Andras Muntag, KTI for valuable input in understanding and adapting the Hungarian calculation methods.

## References

[1] 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, Official Journal L 189, 18/7/2002, P.0012-0025

[2] Commission Recommendation of 6 August 2003 concerning the guidelines on the revised interim computation methods for industrial noise, aircraft noise, road traffic noise and railway noise, and related emission data, notified under document number C(2003)2807, Text with EEA relevance,

2003/613/EC, Official Journal L 212, 22/8/2003, P.0049-0064

[3] LANG, Judith: “Comparison of emission data for road traffic noise in guide de bruit and in the German (RLS 90) and the Austrian (RVS 3.02) calculation model”, “Adaptation and revision of interim computation methods” (AR-INTERIM-CM), internal project communication for Task 3-1-1, Sep./Oct. 2002

[4] TECHNICAL PROPOSAL - Preparation of the calculation method to be used in Hungary concerning different noise sources, to be validated by the Commission of the EU as implementation of the EU Directive on environmental noise, Budapest, November 2003, 25 pages.

[5] Berechnung des Verkehrslärm an Straßen, 13 pages, German translation of part of the Hungarian standard KTI Rt.: Road Technical Rules Ut 2-1.302:2000.

[6] Berechnung des Verkehrslärms bei Schienenwegen, 5 pages, German translation of part of the Hungarian standard KTI Rt.: MSZ 07-2904:1990

[7] Adaptation and Revision of Interim Computation Methods for Strategic Noise Mapping: Final Report - Part A, Wölfel Messsysteme · Software GmbH&Co et al, EC DG Environment research contract B4-3040/2001/329750/MAR/C1, 2003, 144 pages

[8] Strategic Noise Mapping in Hungary: Progress Report A, HURonaszeki15_2040019/EU FCW, Lot 6 Environment, 26 August 2004

[9] ISO 9613-2:1996 (E), Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation, ISO