Comparison between German Road Traffic Noise Calculation Method and new Common Noise Assessment Methods

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Summary

Since 2009, the EU Commission was working on harmonized assessment methods according to Article 6 of the EU Environmental Noise Directive. In July 2014, the Noise Regulatory Committee agreed by a majority on the EU Commission's draft directive for harmonized noise assessment methods according to the EU Environmental Noise Directive. This will be adopted through an amendment of Annex II of the Directive and applied mandatory in 2019 for all Member States.

To assess its proposed policies in a first step, the emission model of the drafted national computation method RLS-16 for road traffic noise is compared in detail to the new method of CNOSSOS-EU. The investigations are carried out based on typical test scenarios. Important parameters such as pavement, speed, slope and junction have been varied. Temperature corrections are considered separately for their effect in the CNOSSOS-EU model.

Based on the results of the comparison, recommendations for the future use of the harmonized assessment method for road traffic noise are given and practical simplifications of the methods for national use are demonstrated.

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1. Introduction

The initiative to create a new, coherent noise policy and consequently the Environmental Noise Directive [1] came from the European Commission in November 1996 with its green paper on "Future Noise Policy" [2]. In it, the European Commission considered it is necessary for the noise pollution situation to be determined in the individual member states according to comparable criteria and procedures, in order on the one hand to obtain as comprehensive as possible an overview of the noise situation in Europe and its impact, and on the other hand to be able to assess the success of Community measures. The work on the development of these methods is known by the acronym CNOSSOS-EU (Common Noise Assessment Methods for Europe) [3].

The aim of CNOSSOS-EU is to enable the calculation and analysis of noise pollution from road traffic, rail traffic, aircraft, and industrial noise for the EU Environmental Noise Directive (END). In July 2014, the Noise Regulatory Committee agreed by a majority on the EU Commission's draft directive for harmonized noise assessment methods according to the END. The new calculation methods will be introduced through an amendment of Annex II of the END and is applied by all Member States as from 01.01.2019 mandatory. Now, the final version [4] of the methods is published and Germany has begun preparations for national implementation.

A comparative examination of the national road traffic noise calculation method RLS-16 (Richtlinien für den Lärmschutz an Straßen) [5] and CNOSSOS-EU shall be conducted below.

2. Description of the calculation methods

2.1 CNOSSOS-EU Road Traffic Noise Source

In the source model "CNOSSOS-EU Road Traffic Noise Source", the vehicles are grouped into four different categories.

Category 1 (Q1):	Light motor vehicle
Category 2 (Q2):	Medium heavy vehicles
Category 3 (Q3):	Heavy vehicles
Category 4 (Q4):	Powered two-wheelers

The latter category is further divided into mopeds/motorcycles with a cylinder capacity ≤ 50 ccm (Q4a) and > 50 ccm (Q4b).

Furthermore, the octave bands from 63 Hz to 8 kHz are used almost throughout for the calculation, and a distinction is made between rolling and propulsion noise.

Rolling noise ($L_{WR,m}$) is modelled as a function of speed with the following formula:

$$L_{WR,m} = A_{R,m} + B_{R,m} \times \lg\left(\frac{v_m}{v_{ref}}\right) + \Delta L_{WR,m}(v_m) \quad (1)$$

$\Delta L_{WR,m}(v_m)$ contains correction terms for the effects of the road surface, the air temperature, crossings (traffic lights, roundabouts) and studded tyres. The coefficients $A_{R,m}$ and $B_{R,m}$, as well as other coefficients required in the correction term are defined in a table for each octave band, differentiated according to vehicle category (represented by index m).

Propulsion noise ($L_{WP,m}$) is determined according to the following formula:

$$L_{WP,m} = A_{P,m} + B_{P,m} \times \frac{v_m - v_{ref}}{v_{ref}} + \Delta L_{WP,m}(v_m) \quad (2)$$

$\Delta L_{WP,m}(v_m)$ represents the sum of the calculated correction values for the road surface, crossings (traffic lights, roundabouts) and the longitudinal gradient of the road. The coefficients $A_{P,m}$ and $B_{P,m}$ as well as other coefficients required in the correction terms are in turn defined in the table for each octave band. The uniform reference speed v_{ref} for all vehicle categories is $70\,km/h$. It should be noted that the spectrum resulting from the energetic summation of the partial sources of all vehicle categories is not yet A-weighted.

2.2 RLS-16

The RLS-16 [5] is the future German method for calculating road traffic noise. In contrast to the CNOSSOS-EU Road Traffic Noise Source, the RLS-16 dispenses completely with spectral aspects. In addition, the calculation method does not distinguish between rolling and propulsion noise. It contains a road surface correction D_{SD}, which is dependent on vehicle speed and on the vehicle category (three categories according to Q1, Q2 and Q3 of CNOSSOS-EU). Slopes and gradients are included in the calculation method by means of the allowance D_{LN}. Supplements for junctions have been considered through the correction D_K. Finally in the case of reverberation a term D_{refl} is added, depending on the geometry in the vicinity of the road.

$$\begin{aligned} L_{WA(FzG,v)} \; = \; & L_{W0A(FzG,v)} + D_{SD(FzG,v)} + D_{LN(FzG,v)} \\ & + D_{K(x)} + D_{refl}(h_{Beb}, w) \end{aligned} \quad (3)$$

L_{W0A} represents the basic value for sound power level per vehicle category (typified by index FzG):

$$L_{W0A(FzG,v)} = A_{WA(FzG)} + 10 \times \lg\left[1 + \left(\frac{v_{(FzG)}}{B_{W(FzG)}}\right)^{C_{W(FzG)}}\right] \quad (4)$$

The coefficients $A_{WA(FzG)}$, $B_{W(FzG)}$ and $C_{W(FzG)}$ are defined in a table for each vehicle category. RLS-16 addresses also the categories light motor vehicle, medium heavy vehicle and heavy vehicle. Powered two-wheelers are considered as heavy vehicles in the calculation.

3. Comparison of CNOSSOS-EU Road Traffic Noise Source with RLS-16

For a comparison of the noise emission models, the directional sound power levels as defined in CNOSSOS-EU Road Traffic Noise Source and RLS-16 are calculated for different emission situations. The situations are defined by road surface, vehicle speed, gradient and crossings whereby in each case one of the input parameters is varied. Supplements for temperature corrections are examined separately in the CNOSSOS model with regard to their impact.

3.1 Situation 1 – Road surfaces

In order to achieve as equal prerequisites as possible for a comparison of both emission models, the road surfaces were first examined. The fundamental difficulty here is finding the equivalent surface in CNOSSOS-EU for the road surfaces in RLS-16. In order to guarantee the comparability of the following results, the RLS-16 stone mastic asphalt (0/8 or 0/11) surface and the CNOSSOS-EU reference road surface were used in all subsequent studies. While these road surfaces display some similarities, they are not identical, so that different levels result from this fact alone. The comparison (Figure 1) shows that for the vehicle categories Q2 and Q3 occurs a large spread in level for higher speed.

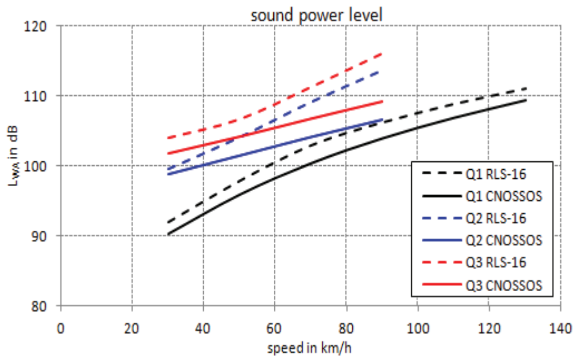

Figure 1: Sound power level depending on road surface for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 with CNOSSOS reference road surface and RLS-16 SMA road surface.

For future calculations according to CNOSSOS-EU the road surface correction D_{SD} must be available as a spectral correction coefficient α in octave bands and as a speed index β for relevant surfaces in Germany. A procedure for creating these coefficients and converting existing data is not known yet. The European Commission promised a converting method will be explained in the not yet published "Guidelines for the competent use of CNOSSOS-EU", with examples for some road surface corrections.

3.2 Situation 2 – Vehicle speed

RLS-16 sets an area of validity for cars at between 30 and 140 km/h and for trucks at between 30 and 90 km/h. CNOSSOS-EU, on the other hand, observes all types of vehicles with a uniform speed range of between 20 and 130 km/h. Therefore, for the purpose of calculation, the maximum speed for trucks or medium goods vehicles was limited to 90 km/h, to guarantee the comparability of the methods.

The results in Figure 2 show that a reduction of truck speed (Q2/Q3) has a greater potential for noise abatement (e.g. measure in noise action plans) in the German method.

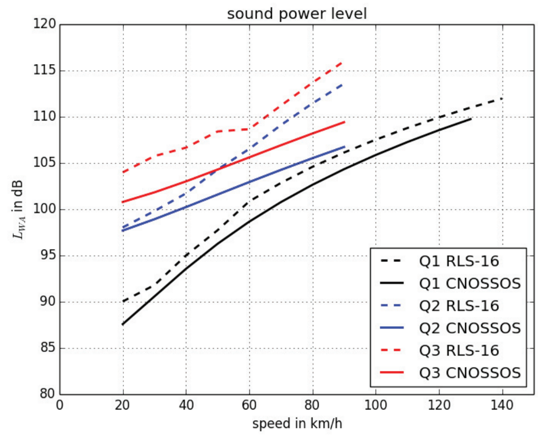

Figure 2: Sound power level depending on speed for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16.

3.3 Situation 3 – Gradient

In order to assess the impact of the gradient correction, detailed calculations were conducted with both models and the results displayed in Figures 3a and 3b.

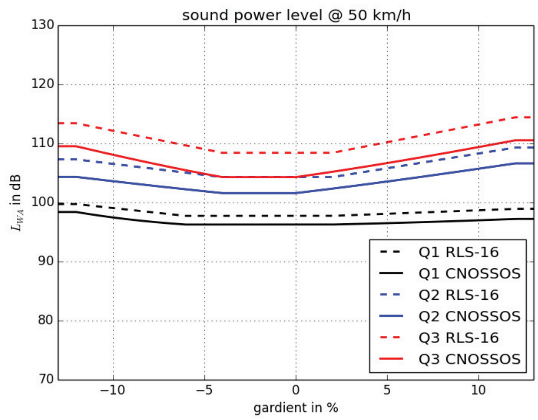

Figure 3a: Sound power level depending on gradient for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS 16 at 50 km/h.

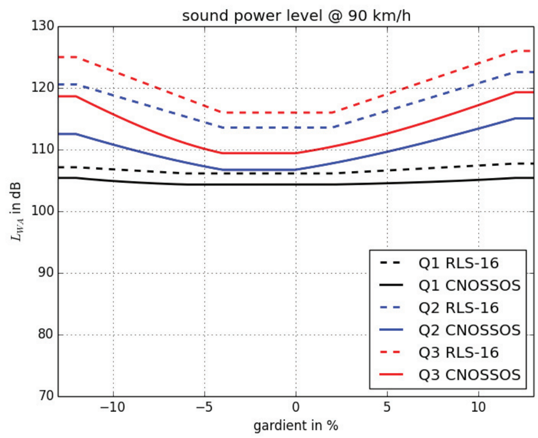

Figure 3b: Sound power level depending on gradient for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 90 km/h.

It can be discerned that CNOSSOS-EU always calculates lower noise emission values than the RLS-16 method. Both models are dependent on the longitudinal gradient of the road and on vehicle speed. It displays a higher supplement for upward than for downward gradients. It is also noticeable that the correction values are limited. The results do not change any further from an upward/downward gradient of 12 %.

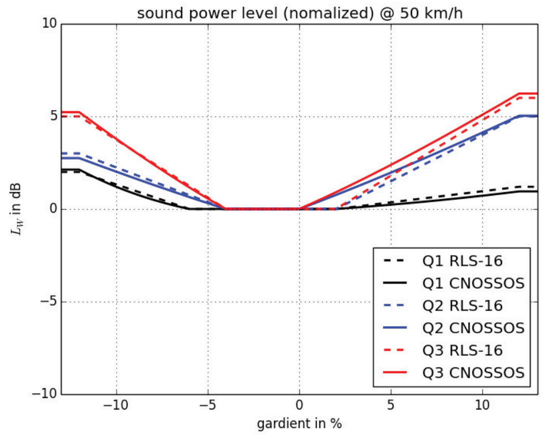

Figure 3c: Sound power level depending on gradient for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 50 km/h; normalized to 0 %.

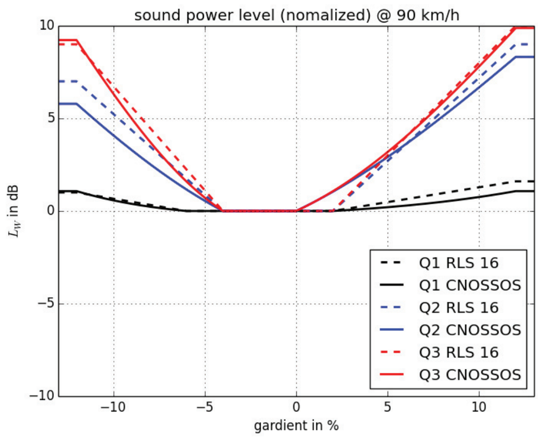

Figure 3d: Sound power level depending on gradient for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 90 km/h; nomalized to 0 %.

If one normalises both curves to s/g = 0 % (see Figure 3c and 3d) in order to better assess the gradient effect, it can be seen that the allowances themselves deviate only slightly from each other, up to +/- 12 %. The capping at 12 % in the models can certainly be applied, as the maximum longitudinal gradients for newly-constructed autobahns, as well as for extensions, conversions and development, are set between 4% and 6%, depending on the draft category.

3.4 Situation 4 – Junction

The impact of a junction was calculated for a crossing with traffic lights. The results for 50 km/h are displayed in Figures 4a.

In Figure 4b the levels normalized to a big distance are shown.

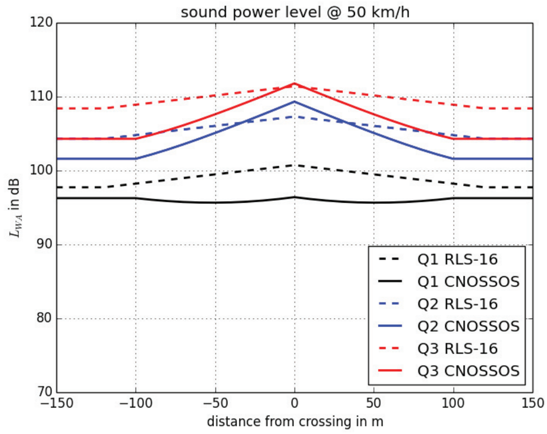

Figure 4a: Sound power level depending on distance to a crossing with traffic lights for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 50 km/h.

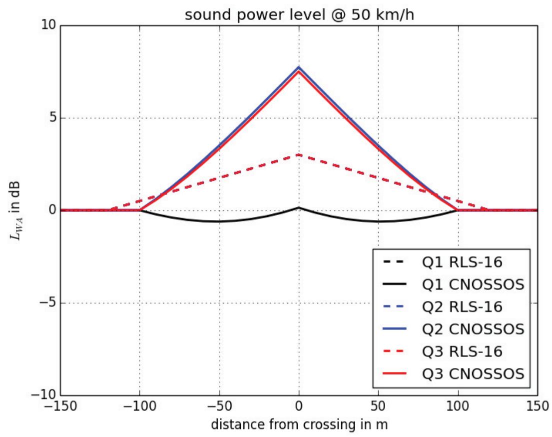

Figure 4b: Sound power level depending on distance to a crossing with traffic lights for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 50 km/h; normalized to a distance of more than 100 m.

There is a big discrepancy between the RLS-16 curves, lying upon each other, and the CNOSSOS-EU curves. For Q1 vehicles they underestimate the level while for Q2 and Q3 vehicles they overestimate it. If we exchange the coefficients $C_{R,m,k}$, and $C_{P,m,k}$, between Q1 on one hand and Q2 and Q3 on the other hand, the results are more realistic (see Figures 4c and 4d).

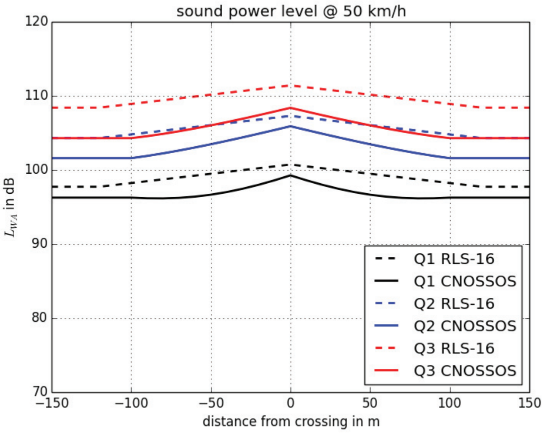

Figure 4c: Sound power level depending on distance to a crossing with traffic lights for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 50 km/h; with changed parameters.

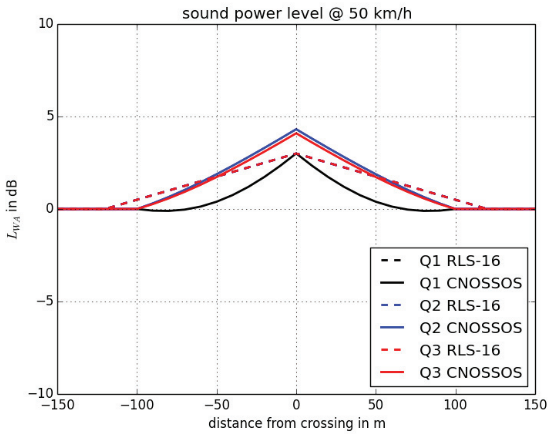

Figure 4d: Sound power level depending on distance to a crossing with traffic lights for vehicles Q1, Q2 and Q3 in CNOSSOS-EU and RLS-16 at 50 km/h; with changed parameters; normalized to a distance of more than 100 m.

3.5 Situation 5 – Temperature

Air temperature has an influence on rolling noise. The higher the air temperature, the lower the sound power level. This effect is taken into account in the CNOSSOS-EU emission model. Road surface coefficients are normally determined at an average temperature of 20 C. If the annual average temperature deviates from this reference value, an adjustment should be made to the correction coefficient.

In order to assess the effect of the temperature correction on rolling noise, average annual temperatures in different German cities that had to create strategic noise maps were taken.

Figure 5 shows that the values with temperature correction differ minimally from each other and from the reference value.

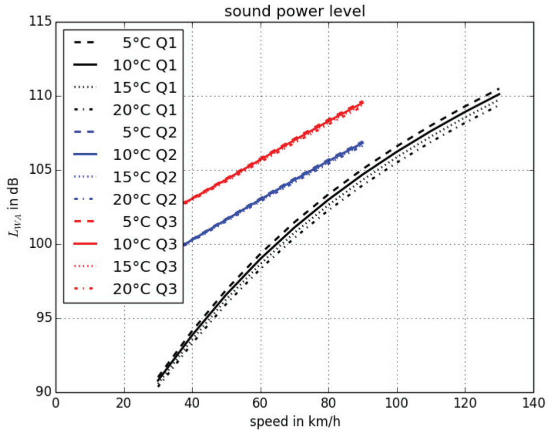

Figure 5: Sound power level depending on speed for vehicles Q1, Q2 and Q3 for different temperatures.

For this reason, the average annual temperature for Germany should be introduced by a default value for future calculations with CNOSSOS-EU.

4. Conclusion

The studies have shown that the emission model of CNOSSOS-EU has a lower sound power level than RLS-16, by up to 6 dB, depending on the situation. Upon the initial application of the noise mapping for Germany in 2022 there must be a precise documentation of all input parameters, in order to enable the calculation to be transparent and comparable. For subsequent noise maps only changes to the input data should be shown. These might include traffic numbers, temperature or substantial changes to routes.

While the CNOSSOS-EU Road Traffic Noise Source Model is a more detailed emission model than RLS-16, the actual number of input values is limited to a similar scale as in the German guidelines (see Table 1). In addition, the assumption of setting some correction values to 0 (e.g. studded tyres) or fixed standard values (temperature, Q4) simplifies the extent of the input data and the calculation. A large difficulty is still presented by the transfer of the road surface corrections into a uniform format, so that they can be used as input data for CNOSSOS-EU.

This report is a first step in comparing the national noise calculation methods with future harmonised calculation methods in a substantiated manner. However, this process has not yet been completed and further studies will follow, e.g. as soon as the road surface corrections have been made available in their final version.

Tabelle 1: Comparison of input parameters

<table>
<tr><td colspan="2">Input parameters CNOSSOS</td><td colspan="2">Input parameters RLS-16</td></tr>
<tr><td rowspan="2">Q_m</td><td rowspan="2">Traffic flow per hour for a vehicle category m</td><td>Decisive hourly traffic intensity</td><td>M</td></tr>
<tr><td>Decisive medium heavy and heavy vehicle proportion</td><td>p</td></tr>
<tr><td>v_m</td><td>Average speed of a vehicle category m</td><td>Permitted maximum speed for vehicle category FzG</td><td>v_{FzG}</td></tr>
<tr><td>$A_{R,i,m}$
$B_{,R,i,m}$</td><td>Rolling noise coefficient per octave band per vehicle category</td><td rowspan="2">Emissions coefficient per vehicle category</td><td rowspan="2">$A_{WA,FzG}$
$B_{W,FzG}$
$C_{W,FzG}$</td></tr>
<tr><td>$A_{P,i,m}$
$B_{,P,i,m}$</td><td>Propulsion noise coefficient per octave band per vehicle category</td></tr>
<tr><td>Q_{stud}</td><td>Average number of cars with studded tyres per hour in the time period T_s</td><td colspan="2" rowspan="5"></td></tr>
<tr><td>T_s</td><td>Time in months</td></tr>
<tr><td>a_i b_i</td><td>Studded tyres coefficient per octave band</td></tr>
<tr><td>K_m</td><td>Temperature coefficient per vehicle category</td></tr>
<tr><td>τ</td><td>Average annual temperature</td></tr>
<tr><td>$\alpha_{i,m}$
$\beta_{i,m}$</td><td>Road surface coefficient per octave band per vehicle category</td><td>Correction for different road surfaces</td><td>D_{SD}</td></tr>
<tr><td>s</td><td>Upward/downward gradient</td><td>Upward/downward gradient</td><td>g</td></tr>
<tr><td>$C_{R,m,k}$
$C_{P,m,k}$</td><td>Intersection coefficient per vehicle category per intersection type</td><td>Intersection coefficient per intersection type</td><td>K_{KT}</td></tr>
<tr><td>x</td><td>Smallest distance between point source and nearest intersection of source lines</td><td>Smallest distance between point source and nearest intersection of source lines</td><td>x</td></tr>
</table>

References

[1] The Environmental Noise Directive (2002/49/EC), 25th June 2002

[2] The Green Paper on Future Noise Policy (COM(96) 540), 4th November 1996.

[3] S. Kephalopoulos, M. Paviotti, F. Anfosso-Lédée: Common Noise Assessment Methods in Europe (CNOSSOS-EU), JRC Reference Report, 2012.

[4] European Commission, Comitology Register; http://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.dossierdetail&TcQY7Y+8YT1iY7i+GWNuvV5r4hpVSI2FBgXx/uXmiouNKP57+JTxf1zsIs1wGLiw, January 2015

[5] Richtlinien für den Lärmschutz an Straßen (RLS 16), draft.