Euronoise 2018
Crete

Evaluation and Validation of the CNOSSOS calculation method in the Netherlands

Tim Vergoed, Hans J.A. van Leeuwen
DGMR Consultants for construction, industry, traffic, environment and software
Casuariestraat 5, P.O. box 370, NL-2501 CJ, The Hague, The Netherlands
+31 88 3467 500, www.dgmr.nl, info@dgmr.nl.

Summary

The new harmonized European calculation method, CNOSSOS-EU, was published in May 2015. This method defines new algorithms for creating strategic noise maps. The new calculation method should be adapted to national legislation before the end of 2018, and applied in the next round of 2021/2022.

In the Netherlands, the CNOSSOS method was also examined with regard to the application for legal purposes. Examples of these purposes are limiting the maximum emission of a road, a railway and an industrial area, and controlling the maximum immission values on façades of houses and other noise-sensitive buildings. This means that there is a so-called narrow or broad implementation of the CNOSSOS method.

Evaluations and validations were carried out for this project. Parts of the calculation method have been tested for plausible results, also in comparison with the existing Dutch SRM2 calculation method for road and rail and the Dutch HMRI calculation method for industrial sources. A report on definitions of quality was the background for these evaluations. The validations were carried out by comparing the complete CNOSSOS method 'as is' with noise measurements in the field. Long-term measurements were preferred for this task. The predefined emission values were important for the validations, but also the demand for the necessary adjustment of these values.

The paper gives some of the findings of the work, the results of this evaluation and validation. This is because of the findings of a top issue in the method: Multiple diffractions under favourable condition.

PACS no. 43.20.El, 43.50.Rq, 43.50.Sr

1. Introduction

The harmonized European calculation method, CNOSSOS-EU, is evaluated and validated for the purposed use for noise maps and for the use with regard to the application for legal purposes. Examples of legal purposes are limiting the maximum emission of a road, a railway and an industrial area, and controlling the maximum immission values on façades of houses and other noise-sensitive buildings.

Evaluations and validations were carried out. Parts of the calculation method have been tested for plausible results, also in comparison with the existing Dutch SRM2 calculation method for road and rail and the Dutch HMRI calculation method for industrial sources. A report on definitions of quality was the background for these evaluations.

The validations were carried out by comparing the complete CNOSSOS method 'as is' with noise measurements in the field. Long-term measurements were preferred for this task. The predefined emission values were important for the validations, but also the demand for the necessary adjustment of these values.

The paper gives some of the findings of the work, the results of this evaluation and validation. This is because of the findings of a top issue in the method: Multiple diffractions under favourable condition. The main issue found as a result of this evaluation and validation work is the problem of the complete incorrect calculation of multiple diffractions under favourable condition. The findings reported in this paper are not, or almost not, affected by this mistake.

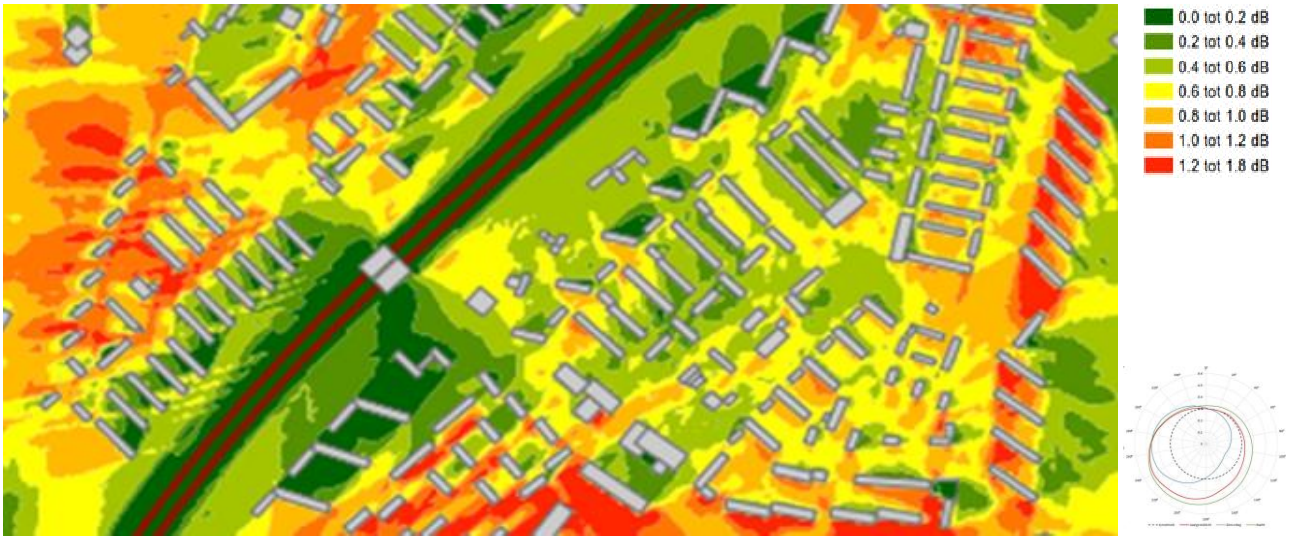

Figure 1. calculations with the CNOSSOS calculation method and the noise level difference symmetrical and asymmetrical compass rose.

2. CNOSSOS and the effect on wind directions

Weather conditions have an significant effect on the propagation of sound in the air. Therefore CNOSSOS implements two types of propagation. Favourable conditions are most common with a downwind while unfavourable conditions occur with upwind or no wind.

In the Netherlands the wind mostly blows from south west to north east. As such buildings east of a highway will encounter higher sound levels on the south east façade. An example of this effect is shown in figure 1. For road noise in this example this effect amounts to 1.8 dB higher levels compared to a homogeneous compass rose.

3. Principles for comparisons and for validations

Statistical approach

In order to make a comparison between the CNOSSOS method and older calculation methods we use a statistical approach to analyse the differences a number of times. This is because in practice there can always be points where larger differences can occur. The results are considered to have a normal distribution. The analyses give an average difference as well as a standard deviation.

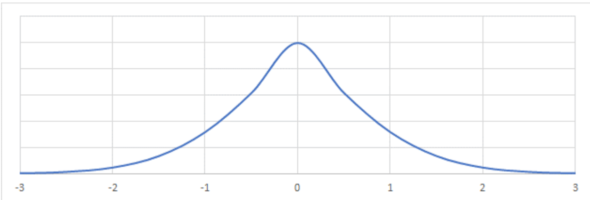

Figure 2. Physical approach to the comparison of empirical calculation methods

What is the true, real noise level?

The approach to reality (real situation) cannot always be determined with measurements. It is therefore good to ask what the reality is of a measurement. The L_{den} and L_{night} could in principle be determined by carrying out measurements for one year, in which case one should also take into account measurement accuracy, disturbance of the source to be measured and representative conditions. There are few possibilities, and there are obstacles to doing this. So also for measurements, this is an approximation of reality. For the time being, we can assume that this is the best approach to reality.

4. Remarks on data input models for calculations

One study of ISPRA was reproduced. For this study noise measurements were performed and amount of cars were counted. This model was created in computer software called CadnA, as shown in figure 2.

The same model was recreated in our computer software called Geomilieu/Predictor.

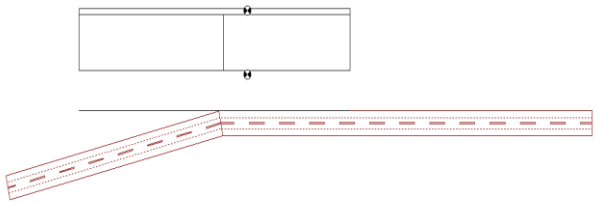

Figure 3. the ISPRA model as was used in the first comparisons.

In both the calculations from ISPRA and DGMR the measurement and calculation at the front of the building were nearly identical. At the back façade of the building in both computermodels, we found an error of 4 dB.

Using satellite imaging the model was expanded, the road was made longer and more detail was added. For instance the buildings behind the main building were previously emitted in the ISPRA model. These buildings provide an additional reflection.

After expanding the model the results at the back façade of the building approached the measurements within 0.3 dB.

These results show that when validating a calculation method like CNOSSOS all details must be taken in account. An incomplete model or a model with inaccurate input data will not lead to correct results.

5. Comparison with SRM and HMRI

Road traffic noise

For a comparison between the SRM calculation method and CNOSSOS the information from the so called `geluidsregister` has been used. This dataset contains the relevant acoustical information of highways and railroads. Also included in this dataset are calculation points spread 100m apart at a distance of 50m from the (rail)roads. A total number of 120000 points where calculated and compared. These results are displayed in the histogram in figure 3.

Railway noise

For railway noise it was found that on average CNOSSOS calculated 1.5 dB higher than SRM (1.6 dB standard deviation).

In the case of road noise CNOSSOS calculated 0.8 dB lower than SRM with a standard deviation of 1.8 dB.

The differences can be accounted to a difference in modelling rules (minimum speed), different spectral emissions and the lack of negative interference in the 500 Hz band.

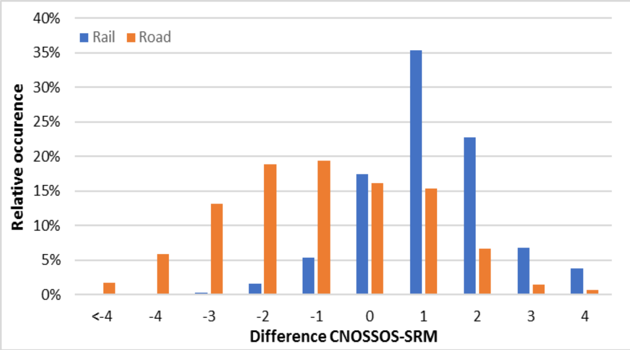

Figure 4. Comparison of CNOSSOS and SRM

Industrial noise

For the industrial zone Botlek-Pernis a total of 75 points, with different heights, were calculated with HMRI and CNOSSOS. For the calculation with HMRI all incompatible elements (vegetation-, terrain- and urban damping) were removed. The calculation was done only for the night period.

For all type of points CNOSSOS calculates an average noise level 3 dB till 11 dB higher than HMRI. For individual points CNOSSOS calculates levels of -1.4 dB till 17.4 dB higher.

These differences are the result of ground attenuation, metrological corrections and multiple diffractions.

6. Comparison with measurements

Road noise

The Dutch health institute (RIVM) have continuously measured the noise levels along parts of the Dutch highways for over a period of about 8 years. Additionally the Dutch Highway institute (RWS) counts the vehicles on the roads. By using these two datasets a comparison between the measurements and CNOSSOS has been made. As most highway surfaces in the Netherlands are pervious concreate and therefore age quicker than

DAC the aging of the road surface was taken into account.

Figure 5. Pictures of both of the situations and overview of models.

The first comparison was made in three rural areas without any relevant buildings and reflective objects. In these areas the modelling of the surrounding is easy as there are hardly any buildings, bridges or height differences. In these situations the differences between the measurements and the calculations with CNOSSOS-EU (so as it was described at the EU) are lower than about 1 dB.

Additionally a comparison was made at two measurement positions in an urban environment. There were several buildings and also some noise barriers, but the microphone has a free sight on the road. Also corrections where introduced due to the aging of the low noise asphalt. The measured sound levels were all slightly higher in relation to the CNOSSOS calculations. This is partly due to small disturbance by trains, planes and local traffic. Though the difference between the measurement and calculation is maxed out at 1.5 dB.

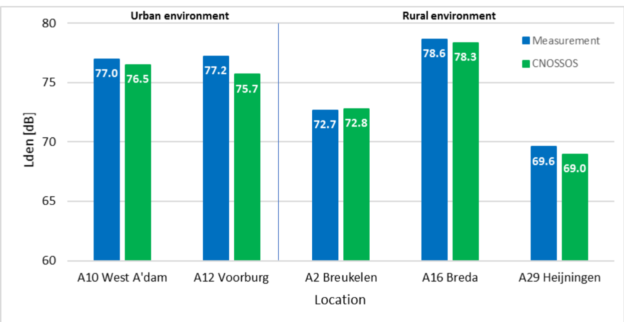

Figure 6. Comparison of CNOSSOS and measurements for road traffic noise.

During this study it was concluded that it is essential when comparing the measurements with calculations the age of the surface must be taken in account to perform a good validation.

Industrial noise

Near the industrial zone Moerdijk some long term noise measurements during the night were performed to validate the sound model. In these measurements a L_{night} of 35 dB(A) was measured.

A calculation with the Dutch method HMRI resulted in a L_{night} of 33.8 dB(A). After removing the vegetation damping (D_{veg}) and the damping by industrial plants ($D_{terrein}$) a value of 36 dB(A) was found. Both these results have a difference of just 2 dB.

A calculation with CNOSSOS resulted in a level of 30.7 dB(A) in homogeneus conditions and 45.7 dB(A) in favourable conditions. As during the night the chance of favourable conditions is about 50% an average immission of 42.8 dB(A) is found.

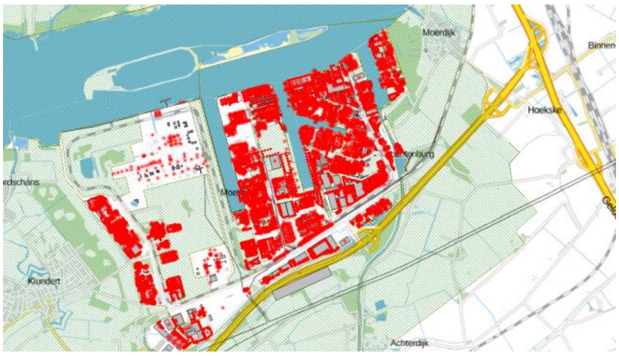

Figure 7. Industrial zone of Moerdijk.

The difference between the measurement and the calculation with CNOSSOS equals 8 dB. This difference is mainly caused by a difference in ground attenuation.

7. Conclusions

Implementing the point-to-point software in regular modelling software is mandatory to make a valid validation. By implementing the calculation method a large number of receiver points can be calculated in different situations. Thus making the sample size for a statistical analysis more representative. And the sensitivity of the calculation method on variation on input data will be tested in practice.

Another key element for validation when comparing to measurements is to make sure that the details are representative. For instance making sure that the percentage of favourable conditions is known and that all the surrounding items are placed in the model. Furthermore when validating for road or rail noise one should correct for the age of the road surface or for the rail roughness.

Is was found, for example that, an incomplete computer simulation model will not lead to correct results. And obviously a model with inaccurate input data cannot give correct results. Garbage in is garbage out!

When comparing CNOSSOS to the current calculation method in use one should be familiar with the particularities, and field of application of each method. For instance the minimum (or maximum) speeds, braking noises and the workings of the ground attenuation.

By implementing the CNOSSOS point-to-point method in regular calculation software a big set of The calculated sound levels do approach the measured sound levels within an expected uncertainty.

The calculation results do approach the measurements for traffic noise quite well. About 95% of all data points have an error of about 2 dB, which can be expected from each calculation method. Most big differences can be explained by particularities of both SRM and CNOSSOS. So this is a very positive result.

For industrial noise the differences between both measurements and older calculation methods are very big. In order to correctly calculate noise levels caused by industrial noise both the ground attenuation and multiple diffraction methods need some tweaking. By adding vegetation damping and industrial plant damping even better results could be found.

These conclusions are under the remark that main findings in this investigation: The incorrectness of multiple diffractions under favourable condition. These conclusions are not affected, or almost not affected by this mistake.

References

[1] European Union; the assessment and management of environmental noise, Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002.

[2] Directive 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council, OJ of the European Communities, July 2015.

[3] Hans J.A. van Leeuwen, Railway Noise Prediction Models: A Comparison, Journal of Sound and Vibration 231 (3) 2000.

[4] Harmonoise WP 3 Engineering method for road traffic and railway noise after validation and fine-tuning HAR32TR-040922-DGMR10 (D18).

[5] Renez Nota, Simon Shilton, Hans J.A. van Leeuwen, et al. (2005) WG-AEN's Good Practice Guide And he Implications For Acoustic Accuracy Final Report: ata Accuracy Guidelines for XPS 31-133, Document ode: HAL 3188.3/8/1 DGMR V.2004.1300.00.R012.1.

[6] Hartog van Banda, Stapelfeldt, "Implementing prediction standards in calculation software, the various sources of uncertainty", Proceedings Forum Acusticum (2005).

[7] Hartog van Banda, S.E.; Implementing noise prediction standards in software, a team effort, Paper BNAM 2010, May 2010.

[8] Hans J.A. van Leeuwen, Tim Vergoed e.a. De nieuwe Europese rekenmethode voor Nederland CNOSSOS-NL - De Evaluatie en Validatie van de methode, DGMR report M.2016.0533.06.R001, 22 december 2017 (in dutch)