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CALCULATION METHODOLOGIES FOR MOTORWAY AND NATIONAL ROADS IN IRELAND: COMPARING CRTN AND CNOSSOS-EU

Enda Murphy,[1*] J.P. Faulkner[1] and E.A. King[2]

[1] University College Dublin, School of Architecture, Planning and Environmental Policy, Belfield, Dublin 4, D14 E099

[2] University of Galway, Discipline of Mechanical Engineering and Ryan Institute, H91TK33 Galway, Ireland

ABSTRACT

In 2009 the European Commission sanctioned the development of CNOSSOS-EU which represents a ratification of article 6.2 of Directive 2002/49/EC proposing a harmonised method for assessing environmental noise in Europe. The paper investigates the most appropriate calculation methodology to be implemented for assessing road traffic noise on motorways and national roads in Ireland. This is achieved by comparing results from CNOSSOS-EU and the previously applied CRTN-TRL Method 1 methodology with sound level meter (SLM) measurements. Overall, the results show that relative to the CRTN-TRL model, the CNOSSOS-EU model converges more closely with measurement data for Irish roads.

Keywords: *noise mapping, cnossos-eu, road traffic noise, crtn.*

1. INTRODUCTION

The negative health impacts associated with the non-auditory effects of environmental noise are now well-established, and negative health impacts caused by there is a burgeoning literature investigating the association between transportation noise and various negative health impacts. With the publication of the WHO [1] *Environmental Noise Guidelines for the European Region* and Commission Directive (EU) 2020/367 [2] outlining assessment methods for calculating the harmful effects of environmental noise, it is evident that transportation noise is now widely considered a serious environmental and health risk factor for the European population. Since 2002, Commission Directive 2002/49/EC, also known as the Environmental Noise Directive (END), has been used for the assessment of environmental noise in Europe. In 2009 the European Commission sanctioned CNOSSOS-EU which proposes an harmonised method for assessing environmental noise in EU MS. Prior to this, EU MS utilised either national calculation methodologies or interim methodologies [3] in the assessment of environmental noise. This paper explores the use of CNOSSOS-EU in the assessment of national road and motorway projects in order to assess how the model aligns and compares with the END and noise health assessments required under Directive [2]. This is achieved by evaluating measurements taken in the field with the UK's Calculation of Road Traffic Noise: 1998 (CRTN) method [4] and the new CNOSSOS-EU method.

2. SUMMARY OF CALCULATION METHODS

The UK's "Calculation of Road Traffic Noise" (CRTN) model has historically been used to calculate road traffic

**Corresponding author*: enda.murphy@ucd.ie

noise in Ireland [4, 5]. Since CRTN predicts noise levels in terms of L_{10}, conversion factor had to be developed to report results in terms of the EU universal indicators L_{den} and L_{night}. Such conversions factors were developed by TRL for in the UK, and subsequently adapted for use in Ireland by [5]. TRL (Transport Research Laboratory Limited) techniques were not created to establish noise standards or limit values for use in highway planning; rather, they were created for the purpose of noise mapping [5]. TRL Method 1 is used for assessing national road projects in Ireland and is applied when hourly traffic count data is available. The CNOSSOS-EU model for road traffic noise divides the physical noise source (i.e. the road) into a collection of incoherent point sources [6]. This enables one to identify the relevant propagation path between the point source and the receiver and facilitates the generation of attenuation for differentiated paths of propagation [7]. CNOSSOS-EU is measured in an octave band frequency range of 63 Hz – 8kHz and, similar to most acoustic prediction methods, is separated into a source model and a propagation model. The CNOSSOS-EU road source model is based on measurements conducted as part of the Harmonoise/IMAGINE project [8], but also utilises NMPB-2008 with respect to certain parameters such as the equivalent road source height [9]. The CNOSSOS-EU propagation model is based on NMPB-2008 [10].

3. TEST CASE ANALYSIS

3.1 Acoustic models and field measurements

In order to analyse CTRN-TRL and CNOSSOS-EU, acoustic test case models based on CRTN-TRL Method 1 [4] and CNOSSOS-EU [11] were generated between 13.02.23 and 17.03.23 using *Predictor-LimA version 2022.1*. Data relating to terrain and ground level parameters were acquired from Transport Infrastructure Ireland (TII). Acoustic models were compared with field measurements recorded by [12]. Test case locations were selected based on the location of the 328 traffic count units that make up TII countrywide network. This enabled cross-validation of traffic count, vehicle classification and average speed. Accessibility and the ability to place microphones close to road sources were also major factors. Type 1 sound level meters were used to record sound levels at roadside. Test Case 1 was located at WGS84 53.943770, -6.417592. Measurements were performed on 26/03/19 from 10:45 to 11:45. In accordance with ISO 11819-1, microphones were intended to be placed 7.5 metres from the centre of the measured lane. However, due to terrain-related obstacles, it was impossible to adhere to this parameter. These problems were prevalent across all potential locations. Roadside microphones were consequently set up at 15 and 9 metres (which was as close as microphones could be positioned) from centre of the measured lane. In accordance with ISO 1996-2:2017/BS 7445-1:2003, all microphones were positioned 1.5 metres above source level. One microphone was set up for propagation analysis 50 metres from centre of the measured lane. Meteorological conditions were measured using a mobile weather station kit and entered into the CNOSSOS-EU model. Video recording equipment was used to count vehicle number, and a handheld speed monitoring device was used to record average speed. Temperature was recorded at 12.71˚C, pressure 103.5kPa, air humidity 58.93%, wind speed <2m/s, wind direction south SE, ground condition dry, and cloud cover partial to complete. Light vehicles (N=643) were travelling at an average speed of 122km/hr and category 2 and 3 (N=167) heavy vehicles were travelling at an average speed of between 90-101km/hr. Test Case 2 was located at WGS84 53.827420 -6.532415. The experiment was performed on 1/06/19 between 07:30 and 09:00. The test case was conducted on a continuously hard ground surface (i.e. $G = 1$) with a propagation distance of 15m from centre of the measured lane. Microphones 1, 2 and 3 were positioned at 7.5m, 10m and 15m from the centre of the measured lane. Temperature was recorded at 22.5˚C, pressure 101.3kPa, air humidity 42.84%, wind speed <2m/s, wind direction west, ground condition dry, and cloud cover clear. Light vehicles (N=662) were travelling at an average speed of 87km/hr and category 2 and 3 heavy vehicles (N=82) were travelling at an average speed of between 79-81km/hr.

3.2 Vehicle classifications and road surface type

The CRTN model divides cars into two categories: light and heavy. In contrast, the CNOSSOS-EU model makes use of five different types of vehicle categorises (see [13]; L 168/6). Road surface correction coefficients utilised for acoustic modelling followed recommendations reported for interim road surface correction factors for national roads in Ireland (see [14]; 12). According to TII, Hot Rolled Asphalt (HRA) is predominately used as a road surface material on national and regional road networks outside agglomerations and it was therefore assumed that HRA was the most likely road surface present in the test case locations. Therefore, correction coefficients applicable for a HRA road surface was applied for acoustic modelling [15].

4. RESULTS

The results of field measurements conducted during the Test Case 1 motorway experiment and in respect to CRTN-TRL Method 1 and CNOSSOS-EU are described in Table 1. The Table shows that, during non-continuous traffic flow with vehicles travelling between 90 km/h and 122 km/h CRTN-TRL Method 1 underestimated by -9.4, -8.8 and -0.3 dB(A) 15m, 9m and 50m from road centreline, while the CNOSSOS-EU model underestimated by -4.2 dB(A) 15m and 9m from road centreline and overestimated by 1.9 dB(A) 50m from road centreline.

Table 1: Test Case 1 M1 Motorway Results

Position	SLM	CRTN	CNOSSOS	CRTN	CNOSSOS	CNOSSOS/CRTN
				Differential		
1(15m)	79.4	70	75.2	-9.4	-4.2	5.2
2(9m)	82.3	73.5	78.1	-8.8	-4.2	4.6
3(50m)	62.1	61.8	64	-0.3	1.9	2.2

Table 1 also shows that at 15m and 9m from road centreline the CNOSSOS-EU model is 5.2 dB(A) and 4.6 dB(A) closer to field measurements than CRTN-TRL. At 50m from road centreline CRTN-TRL is 1.6 dB(A) closer to field measurement relative to CNOSSOS-EU. This suggests that, generally, CNOSSOS-EU is more closely aligned with the END and [2], and that both calculation methods align more closely with field measurements at distances away from the source. The results of field measurements conducted during the Test Case 2 national road experiment and in respect to CRTN-TRL Method 1 and CNOSSOS-EU are described in Table 2. Table 2 shows that, during a non-continuous traffic flow scenario with vehicles travelling between 79 km/h and 87 km/h CRTN-TRL Method 1 underestimated by -8, -6.8 and -2.5 dB(A) 7.5m, 10m and 15m from road centreline. Table 2 also shows that the CNOSSOS-EU model underestimated by -4.3 and -2.4 dB(A) 7.5m and 10m from road centreline and overestimated by 2.7 dB(A) 15m from road centreline. At 7.5m and 10m from road centreline the CNOSSOS-EU model is 3.7 dB(A) and 4.4 dB(A) closer to field measurements than CRTN-TRL. At 15m from road centreline CRTN-TRL is 0.2 dB(A) closer to field measurements than CNOSSOS-EU. Again, this suggests that, generally, CNOSSOS-EU model is more closely aligned with the END and [2], and that both models align more closely at distance away from source.

Table 2: Test Case 2 N2 Results

Position	SLM	CRTN	CNOSSOS	CRTN	CNOSSOS	CNOSSOS/CRTN
				Differential		
1(7.5m)	77.8	69.8	73.5	-8	-4.3	3.7
2(10m)	74.7	67.9	72.3	-6.8	-2.4	4.4
3(15m)	67.6	65.1	70.3	-2.5	2.7	5.2

5. DISCUSSION AND CONCLUSION

Results indicate that in the context of vehicles travelling at medium to high velocity on motorways and national roads in Ireland, CNOSSOS-EU generated results that were closer to field measurements relative to the CRTN-TRL Method 1, which has been the traditional method used in calculating road traffic noise in such scenarios. The difference in model results was notable with CRTN-TRL diverging considerably compared to field measures and relative to CNOSSOS-EU.

Although CNOSSOS-EU converges closer to field measurements relative to CRTN, practitioners should also be aware that CNOSSOS-EU, like all acoustic calculation models, also exhibits technical limitations which may be improved in future revisions of the model. The CNOSSOS-EU model still underestimates road traffic noise by up to -4.3 dB(A) in the scenarios described, and therefore may require further revision going forward. In order to ascertain the direction that such revision may take it is important to consider other national and international research in the area. Accordingly, [15] found that, in France, vehicles travelling at higher speeds underestimated noise emissions by up to 4 dB(A) LA_{eq}. Nevertheless, despite the technical limitations associated with CNOSSOS-EU, such disadvantages are not uncommon with a wide range of national calculation methodologies and, as discussed, such limitations are much more apparent in the case of the previously utilised CRTN-TRL Method 1. Furthermore, CNOSSOS-EU is a far more versatile method than CRTN, e.g. CRTN predicts noise in terms of L_{10} which then has to be converted to L_{den} and cannot account for separate speeds in respect to light and heavy vehicles, whereas CNOSSOS-EU can; CNOSSOS-EU also performs calculations across frequencies whereas CRTN only performs A-weighted calculations.

The purpose of this paper was to assess how CNOSSOS-EU performs in the context of national and motorway road projects to allow alignment and comparison with the END and [2]. In this respect it was found that the CNOSSOS-EU method [12] aligns more closely with the END and [2] than the previously used calculation method for Ireland CRTN.

6. ACKNOWLEDGEMENTS

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