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EVALUATION OF ROAD NOISE PREDICTION MODELS IN IRELAND: A COMPARISON OF CNOSSOS-EU AND CRTN SOURCE MODELS

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ABSTRACT

This study evaluates the performance and applicability of road traffic noise models, with a primary focus on CNOSSOS-EU (Common Noise Assessment Methods in Europe) and CRTN (Calculation of Road Traffic Noise) in the context of Ireland. CNOSSOS-EU, developed for the European Commission, offers a standardised and detailed framework for noise assessment, incorporating parameters such as vehicle type distributions, road surface characteristics, and environmental factors. In contrast, CRTN, established in the UK in 1988, provides a simplified approach to road traffic noise prediction. A pilot investigation examines the CNOSSOS-EU source model for Ireland by examining traffic flow dynamics, including vehicle quantity, speed, and type variations, and analysing predicted versus measured noise variances. Results are compared to the CRTN method where appropriate. This study supports its use in Ireland as explored factors such as traffic characteristics and road surface corrections for Irish road network.

Keywords: *road traffic model, road noise, environmental noise, CRTN, CNOSSOS-EU*

1. INTRODUCTION

The Environmental Noise Directive (END), established in 2002 [1], transposed to Irish law through the European Communities (Environmental Noise) Regulations 2006 (S.I. No. 140 of 2006) [2], required EU Member States to assess and manage environmental noise through strategic noise mapping. This directive laid the foundation for a more harmonised approach to noise monitoring, involving standardised methods for calculating and reporting noise levels. As a result, countries began to shift from using region-specific methods like Calculation of Road Traffic Noise (CRTN) (Department of Transport and Welsh Office, 1988) [3] to a more robust, widely applicable model, capable of accommodating a broader range of noise sources (e.g., road, rail, and air traffic).

For the early rounds of noise mapping under the END, CRTN was used to create strategic noise maps for road traffic sources in Ireland. More recently, since Round 4 the CNOSSOS-EU model has been used, in line with the requirement to transition to consistent models across the region. Thus, CNOSSOS-EU [4] has become the new standard for strategic noise mapping, replacing methods like CRTN for broader noise assessments. CNOSSOS-EU incorporates a more detailed set of parameters and is intended for use with a wide range of noise sources.

1.1 CNOSSOS-EU

CNOSSOS-EU was developed for the European Commission and published as a directive in July 2015 [5]. It aims to standardise European noise assessment methods. This comprehensive framework incorporates detailed parameters, such as vehicle type distributions, road surface types, and environmental factors, to ensure consistency and reliability in strategic noise mapping and action planning.

The methodology was developed through a collaborative effort involving scientific experts, policymakers, and industry stakeholders, with its foundation rooted in robust acoustical science and modelling principles. The initial draft of CNOSSOS-EU was published in 2012 [3], and technical guidance was provided to support its implementation. The methodology was refined with contributions from EU bodies such as the Joint Research Centre (JRC) in

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collaboration with Member States and organisations like the World Health Organization (WHO) and the European Environment Agency (EEA). After reviewing and consultation, the method was finalised and published as a Directive in July 2015.
By harmonising methodologies, CNOSSOS-EU has improved European noise assessments' comparability and scientific rigour. This unified approach allows Member States to evaluate the effectiveness of noise action plans better and align their efforts with the objectives of the END. Additionally, CNOSSOS-EU facilitates more effective cross-border collaboration and provides a robust foundation for managing environmental noise at the European level.

1.2 CRTN

The CRTN method was developed by the UK Department of Transport (DoT) and the Welsh Office in the early 1980s. It was primarily designed to estimate road traffic noise levels based on factors such as traffic flow, vehicle types, road layout, and environmental conditions. CRTN is a simpler and more practical model than other noise prediction methods, particularly for the UK's specific traffic and road conditions. The method incorporates a set of fixed assumptions and input parameters tailored to provide reliable results for the UK's needs.
CRTN was widely used in the UK (and Ireland) as a standard for road traffic noise prediction and was employed for various noise-related studies and projects. However, with the implementation of the European Union's END, the method is being gradually phased out in favour of more comprehensive and standardised models.

2. SOURCE MODEL

2.1 CRTN Source Model

The CRTN method calculates a basic noise level from empirical data and adjusts it for road type and traffic composition. Propagation corrections account for distance attenuation, ground effects, barriers, reflections, and meteorological conditions. These factors combine to estimate noise levels at a receiver.
The CRTN source model calculates noise levels at a reference position of 10 meters from the nearside carriageway edge and at a height of 0.5 meters, which serves as the basis for further propagation corrections, and it calculates the basic noise levels per segment. CRTN states that when noise levels vary significantly along a road due to changes in traffic conditions, road gradient, curvature, or screening, the road should be divided into segments where the noise variation within each remains below 2 dBA. Each segment is then treated as a separate source, with its noise contribution assessed individually.
In assessments performed for this paper, only one segment is considered, and it is considered that the road model does not present changes in traffic conditions, curvature, etc.
CRTN categorises vehicles into two main groups as:

- Light vehicles: This category includes private cars and light vehicles.
- Heavy Vehicles: This includes vehicles with an unladen weight exceeding 1525kg.

2.2 CNOSSOS-EU Source Model

The CNOSSOS-EU source model characterises road traffic noise emissions based on vehicle category, speed, and road surface type, with emissions defined as frequency-dependent sound power levels (L_w). Inputs include traffic flow (veh/h), percentage of heavy vehicles, speed, acceleration, road gradient, and surface type, which influence both rolling and propulsion noise components. The model outputs sound power levels per octave band (63 Hz to 8 kHz) at a reference height, typically around 0.05 m for rolling noise and 0.3–0.75m for propulsion noise, depending on the vehicle type. Unlike CRTN, which uses empirical adjustments, CNOSSOS-EU adopts a physics-based approach, allowing for more detailed spectral analysis and better integration into European environmental noise assessments.
CNOSSOS-EU has five different vehicle categories, while CRTN only considers two, as CRTN simplifies the classification by grouping all heavy vehicles. CNOSSOS-EU vehicles are grouped into four categories based on their noise emission characteristics, as presented below. There is a fifth category that will allow future novel noise sources to be included:

- Category 1: Light motor vehicles
- Category 2: Medium heavy vehicles
- Category 3: Heavy vehicles
- Category 4: Powered two - wheelers:
    - 4a mopeds, tricycles or quads ≤ 50 cc
    - 4b motorcycles, tricycles or quads > 50 cc

2.3 Test Conditions

It is important to emphasise that CNOSSOS-EU and CRTN define the noise source differently: CNOSSOS-EU predicts a sound power level per meter of road ($L_{w/m}$), while CRTN calculates a sound pressure level ($L_{A10,1hr}$) at a reference position 10m for the road edge. Therefore, absolute values between the two models are not directly comparable.

Instead, the focus should be on the trends and differences between each prediction.

Tab. 1 presents the source characteristic that defines the reference conditions of a sample road to which deviation will be compared.

Table 1. Characteristics of Reference Road.

Source Variable	Details	Value
Total number of vehicles in flow	Per hour	10000
Average traffic speed	Km/hr	90
Percentage of heavy vehicles (HGVs)	%	30
Gradient of Road	Degrees	0
Texture depth	mm	1[1]

In this assessment, we will present different cases, the results for both methods and a comparison of how both methods change depending on the variables.
As presented above, both methods cannot be compared directly; therefore, the change per method and its trend are comparable. Also, the difference between both models has been normalised to the initial value (closest to road) and presented for different cases when appropriate.
It is understood that heavy vehicles in Ireland cannot drive at a speed of 120km/hr. Therefore, to keep consistency between both methods, the speed in reference is 90km/hr, as CRTN cannot differentiate between different speeds for different vehicle types (light and heavy). CNOSSOS-EU can differentiate as the method calculates the sound power per vehicle category. However, for consistency, a 90km/hr target speed has been modelled for Category 3 vehicles.
The results presented here, otherwise presented differently, only present CNOSSOS-EU results with vehicles in Category 1 and 3 to keep the same type of vehicles as CRTN.
Different cases have been modelled, each focusing on the variation of a specific variable. In the first case (Traffic Flow Impact Case 01), traffic flow was varied from 1,000 to 10,000 vehicles in increments of 1,000 to assess its impact on noise levels. In the second case (Vehicle Speed Impact Case 02), vehicle speed was adjusted from 20 km/h to 120 km/h in steps of 10 km/h to explore how speed changes affect noise emissions. The third case (Heavy Vehicle Percentage Impact Case 03) examined the effect of varying the percentage of HGVs in the traffic flow from 0% to 100% to evaluate how the proportion of heavy vehicles influences noise levels.
In the fourth case (Road Surface Impact Case 04), the impact of road surface type was investigated. CRTN varied the texture depth of the road surface, ranging from 1mm to 5mm in steps of 0.5mm, to assess its influence on tyre/road noise. In contrast, CNOSSOS-EU used Irish surface corrections for three types of road surfaces: Hot Rolled Asphalt (HRA), Stone Mastic Asphalt 10mm (SMA10), and Stone Mastic Asphalt 14mm (SMA14).
Finally, in this case (Gradient Impact Case 05), the road gradient was varied between -15% and 15%, allowing for an analysis of both downward and upward slopes and their impact on noise propagation. Each case was designed to isolate the effect of one specific variable, providing a detailed insight into how these factors influence noise predictions in both CRTN and CNOSSOS-EU.

3. RESULTS

In the first case, Case 01, presented in Fig. 1, the variation in noise levels is associated with the variance of traffic flow (Q). Both methods respond identically to changes in traffic flow, as the normalised difference is around 0.

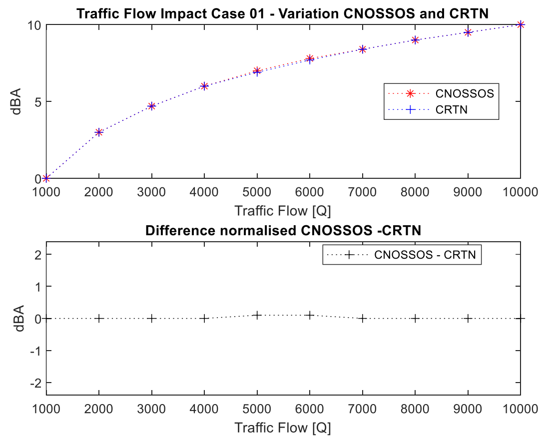

Figure 1: Variation of both Methods for Case 01.

In Fig. 2, we present the results for both methods for Case 02 when varying the speed from 30km/hr to 120km/hr in steps of 10km/hr. We can conclude that both methods present higher levels when the speed increases, however CNOSSOS-EU shows a bigger increase than CRTN, this could be for the contribution of rolling noise that CNOSSOS-EU takes into consideration while CRTN does not differentiate types of noise related to propulsion and rolling.

[1] Value only for CRTN. CNOSSOS-EU provides road surface correction coefficients (α and β) only for Category m=1.

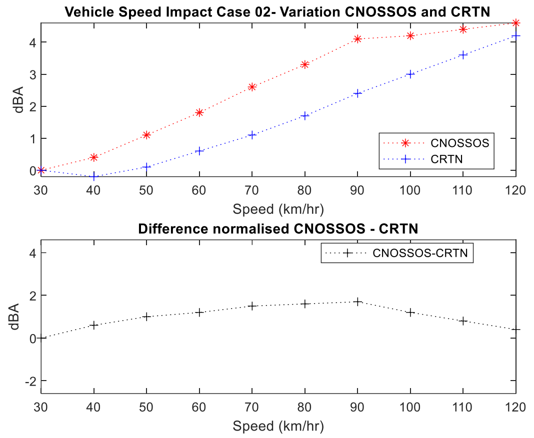

Figure 2: Variation of both Methods for Case 02.

In Fig. 2, an increasing variation between the two methods is observed from 30km/hr to 90km/hr, with the variation being slightly greater in the CNOSSOS-EU results.
As stated before, as a target speed of 90km/hr is set up for heavy vehicles, Category 3 in CNOSSOS-EU, after that speed, the contribution of heavy vehicles remains the same and therefore, the noise levels do not continue with the same increase trend, that with lower speeds as presented in Fig. 2.
This is only considered in CNOSSOS-EU results, as CRTN the potential limitation as the speeds for light and heavy vehicles cannot be input as separate variables and, as such, the impact that changes in the HGV speed limit might have on noise levels cannot be addressed directly. Therefore, in this case, Case 02, the contribution of vehicles of Category 3 in CNOSSOS-EU has a lower increase from speeds higher than 90km/hr. In contrast, CRTN has the same trend in the increase, which is why the difference between both methods decreased from speeds above 90km/hr.

Fig. 3 shows how both methods treat changes in the percentage of HGVs differently. CRTN increases more when the percentage of HGVs increases.
The trend observed, where CRTN increases more than CNOSSOS-EU as the percentage of HGVs rises, can be explained by the differences in the methodologies of these two noise assessment models. CRTN, being an older method, places greater emphasis on the impact of heavy vehicles on traffic noise, as it tends to penalise them more due to their larger size and power and also accounts for both rolling and propulsion noise. On the other hand, CNOSSOS-EU as it differentiates both types of noise from HGVs results in a less pronounced increase in noise levels. Thus, the more significant increase in CRTN can be attributed to its greater sensitivity to HGVs, particularly in terms of both rolling and propulsion noise, whereas CNOSSOS-EU's differentiation leads to a less aggressive increase in noise levels as HGV percentages rise.

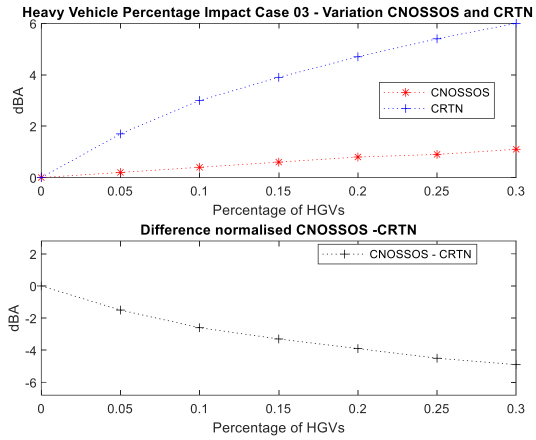

Figure 3: Variation of both Methods for Case 03.

For Case 04, we separate the graphs for both methods as they have different inputs. CRTN can change the value of the texture depth. Fig. 4 shows the variance in the CRTN method when the texture depth increases from 1mm to 5mm in steps of 0.5mm.

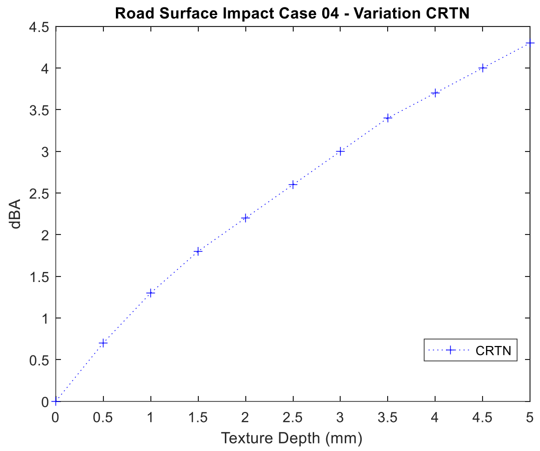

Figure 4: Variations of CRTN method for Case 04.

The texture depth is used as an indication of the state of wear of a road surface and its likely resistance to skidding. As such, it is expected that different values for texture depth will result in a different tyre/road noise level. The texture depth correction is applied to roads impervious to water with a traffic speed greater than 75km/hr. If the speed is less than 75km/hr, a correction of -1dB is applied for impervious bituminous road surfaces, while a correction of -3.5dB is applied to pervious road surfaces. As the average speed is presented as 90km/hr, those corrections cannot be applied to this case, Case 04.

The reference road surface used in CNOSSOS-EU is *'a virtual reference road surface, consisting of an average of dense asphalt concrete 0/11 and stone mastic asphalt 0/11, between 2 and 7 years old and in a representative maintenance condition.'*. Where '0/11' denotes the min/max stone aggregate size, i.e., between 0 and 11 mm, which is also commonly abbreviated with just '11', e.g., SMA11 for stone mastic asphalt 0/11. This reference has been applied to Category 1 vehicles in all the previous predictions because the rolling noise is the dominant source for passenger cars, and the pavement type highly influences it. For m=2 and m=3 (medium and heavy vehicles), the total noise is more affected by engine and exhaust noise, making the impact of pavement variations less significant. Instead of α and β, CNOSSOS-EU uses general coefficients A and B for these categories to model the overall noise behaviour without specific pavement corrections.

In Ireland, Transport Infrastructure Ireland (TII) [6] developed road surface corrections for the Irish network's three most common pavement types:

- Hot Rolled Asphalt (HRA)
- Stone Mastic Asphalt 14 mm (SMA14)
- Stone Mastic Asphalt 10 mm (SMA10)

HRA, SMA10 and SM14 differ in their sound absorption properties and resulting noise levels. HRA is the least absorbent, as its dense and smooth surface reflects more sound, leading to higher noise levels. In contrast, SMA10 has a more open texture, making it the most absorbent of the three and the quietest. SMA14, with its larger aggregate size, is less absorbent than SMA10 but still performs better than HRA in reducing noise.
A 2024 report from TII [5] presented measurements conducted on different roads in Ireland to establish the Surface correction factors for each type of road.
Road surface correction factors are given for light vehicles (Category 1), medium-heavy vehicles (Category 2), and heavy vehicles (Category 3).
As the sound power emissions of medium-heavy and heavy vehicles are different, as are the relative contributions of rolling and propulsion noise, the calculation procedure presented in the report leads to different road surface corrections for medium-heavy and heavy vehicles.

Only Categories 1 and 3 have been considered from all the predictions, so only those categories are presented in these results.
For SMA14, results based on the average result for all SMA14 sections ('SMA14') are given, as well as for the subsets of new and medium-aged surfaces ('SMA14 new' and 'SMA14 medium'). In this assessment, only SMA14 results are presented, discarding the values for new and medium-aged surfaces.
Separate corrections are therefore given for these categories and are detailed in [5].
As there are no corrections for vehicles in Category 4, we will present the comparison only when the traffic flow is 70% of Category 1 and 30% of Category 3. The results are presented in Fig. 5.

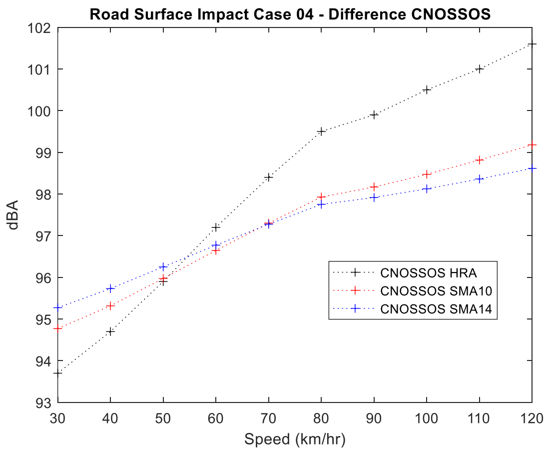

Figure 5: Variation for CNOSSOS-EU for Case 04.

The CNOSSOS-EU model predicts higher noise levels for HRA (Hot Rolled Asphalt) than SMA10 and SMA14 at speeds above 60–70 km/h due to the increasing dominance of rolling and aerodynamic noise. At lower speeds, tyre vibrations influence noise generation, where differences between surfaces are less pronounced. However, as speed increases, rolling noise becomes the primary contributor, and HRA's rougher texture leads to greater tyre vibrations and air-pumping effects, amplifying noise levels. Additionally, aerodynamic noise grows significantly with speed and is higher on HRA due to its irregular surface disrupting airflow more than the smoother SMA10 and SMA14. Unlike SMA surfaces, which have better void structures that help absorb some noise, HRA is denser and more reflective, increasing noise emissions. These combined effects explain why CNOSSOS predicts higher noise levels for HRA beyond 60–70 km/h than SMA10 and SMA14.

For the last case, Case 05, we will analyse noise levels as the gradient varies from -15% to +15%, covering both downward and upward slopes. This range allows us to examine how noise levels are affected by different road gradients, including both steep descents and inclines, which are typically encountered in more rugged or mountainous areas. Considering this gradient spectrum, we can better understand how topography influences sound propagation and noise predictions.

As presented in Fig. 6 the key differences between CRTN and CNOSSOS in calculating gradients lie in their approach and the factors they incorporate. CRTN uses a more straightforward method, assuming a constant gradient without detailed adjustments for changes in slope along the road. It applies a uniform approach to gradient without considering the effects of positive or negative slopes on noise propagation. In contrast, CNOSSOS-EU is more detailed, dynamically adjusting for varying gradients and considering how upward and downward slopes influence sound. Specifically, CNOSSOS-EU predicts higher noise levels when the gradient is negative (i.e., a downward slope) compared to when the gradient is zero due to how sound is focused and directed towards lower elevation areas. Thus, CNOSSOS-EU provides a more nuanced and accurate representation of how different gradients affect noise levels.

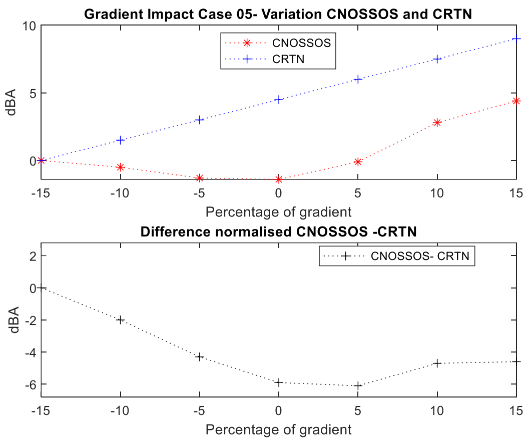

Figure 6: Variation of both Methods for Case 05.

4. INITIAL OBSERVATIONS AND CONCLUSIONS

This study demonstrates that while the fundamental principles of noise generation are consistent across both calculation models, notable discrepancies in results arise. The key findings from the analysis are as follows:

Traffic Flow Impact (Case 01): Both CRTN and CNOSSOS-EU exhibit similar responses to variations in traffic flow, with the normalised difference between the models remaining close to 0, indicating a comparable effect on noise levels.

Vehicle Speed Impact (Case 02): Both methods show an increase in noise levels as vehicle speed increases; however, CNOSSOS-EU presents a plateau in noise levels for Category 3 vehicles beyond 90 km/h due to the model's specific treatment of heavy vehicles.

Heavy Vehicle Percentage Impact (Case 03): CRTN displays a more significant increase in noise levels as the proportion of heavy vehicles rises, owing to its greater sensitivity to heavy vehicle noise. In contrast, CNOSSOS-EU incorporates modern vehicle noise reduction technologies, leading to a less pronounced increase in noise levels.

Road Surface Impact (Case 04): CRTN employs general assumptions for road surface type corrections, while CNOSSOS-EU applies more detailed, surface-specific corrections, particularly for heavy vehicles.

Gradient Impact (Case 05): The analysis spans a gradient range from -15% to 15%, exploring both downward and upward slopes. CNOSSOS-EU predicts higher noise levels for negative gradients, as sound is focused on lower elevations. In contrast, CRTN uses a more straightforward approach, assuming a constant gradient with no specific adjustment for varying slopes.

These findings highlight key differences between the two models, with CNOSSOS-EU offering a more detailed approach to noise prediction. While this study focused on variations in traffic flow, speed, road surface corrections, and gradients, CNOSSOS-EU accounts for additional factors like acceleration, deceleration, studded tyres, and temperature, making it a more comprehensive model.

A notable distinction is that CRTN shows greater sensitivity to heavy vehicle noise, whereas CNOSSOS-EU responds more to speed variations by distinguishing between rolling and propulsion noise. Additionally, its surface-specific corrections make it more adaptable to different pavement types, which is particularly relevant in urban noise management.

Further refining CNOSSOS-EU's parameters to reflect Irish road conditions and vehicle fleets could enhance its accuracy for national noise assessments. This study provides a solid foundation for future evaluations, with key next steps including the development of a strategic noise map, a review of meteorological data, and an analysis of traffic flow patterns most representative of Irish roads.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] European Parliament and Council of the European Union, Directive 2002/49/EC Relating to the Assessment and Management of Environmental Noise, Official Journal of the European Communities, 2002.

[2] European Communities (Environmental Noise) Regulations 2006, S.I. No. 140/2006.

[3] UK. Department of Transport, Calculation of Road Traffic Noise (CRTN), 1988.

[4] European Commission, Common Noise Assessment Methods in Europe (CNOSSOS-EU), 2012

[5] European Commission, Common Noise Assessment Methods in Europe (CNOSSOS-EU) - 2015 Update, 201

[6] Transport Infrastructure Ireland, Determination of Irish Road Surface Correction Factors for CNOSSOS, GE-ENV-01108, May 2024.