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Transitioning to Strategic Noise Mapping under CNOSSOS-EU (Noise-Adapt)

Authors: Enda Murphy, Jon-Paul Faulkner, Henry J. Rice and John Kennedy

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Government of Ireland

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EPA RESEARCH PROGRAMME 2021–2030

Transitioning to Strategic Noise Mapping under CNOSSOS-EU (Noise-Adapt)

(2017-HW-MS-9)

EPA Research Report

Prepared for the Environmental Protection Agency

by

University College Dublin and Trinity College Dublin

Authors:

Enda Murphy, Jon-Paul Faulkner, Henry J. Rice and John Kennedy

ENVIRONMENTAL PROTECTION AGENCY
An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699
Email: info@epa.ie Website: www.epa.ie

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This report is based on research carried out/data from 1 February 2018 to 1 May 2020. It does not reflect more recent policy developments relevant to R4 strategic noise mapping, such as the revisions to CNOSSOS-EU by means of a delegated directive amending Annex II of Directive 2002/49/EC, and the revised EEA Reportnet 3 reporting mechanism as a result of Regulation (EU) 2019/1010.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Project Partners

Enda Murphy
School of Architecture, Planning and Environmental Policy
University College Dublin
Dublin
Ireland
Email: enda.murphy@ucd.ie

Jon-Paul Faulkner
School of Architecture, Planning and Environmental Policy
University College Dublin
Dublin
Ireland
Email: jon.faulkner@ucd.ie

Henry J. Rice
School of Engineering
Trinity College Dublin
Dublin
Ireland
Email: hrice@tcd.ie

John Kennedy
School of Engineering
Trinity College Dublin
Dublin
Ireland
Email: kennedj@tcd.ie

Eoin King
Department of Mechanical Engineering
University of Hartford
West Hartford, CT
USA
Email: eoking@hartford.edu

Francesco Pilla
School of Architecture, Planning and Environmental Policy
University College Dublin
Dublin
Ireland
Email: francesco.pilla@ucd.ie

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Executive Summary

The Noise-Adapt (Ireland) project[1] aims to provide transitional needs assessment and guidance for adapting to CNOSSOS-EU (Common Noise Assessment Methods in Europe) in the Irish context for road and rail sources, including the administration of the standardised approach for population exposure estimation under CNOSSOS-EU. This final report summarises the main research findings and outlines the associated recommendations.

Chapters 2 and 3 of this report present a data needs section for road and rail sources as well as recommendations for data input where Irish data are unavailable. In the context of road sources, recommendations are provided in relation to the categorisation of heavy vehicles (i.e. categories 2 and 3) as well as category 4 vehicles, vehicle speed and the identification of traffic light and roundabout intersections.

Chapter 4 summarises results from the application of CNOSSOS-EU for road and rail sources in Ireland. In the context of road sources within agglomerations, experiments indicated that the CNOSSOS-EU model converged closely with direct measurements [within 0.1–2 decibel(A) – dB(A)],[2] whereas outside agglomerations the CNOSSOS-EU model converged less accurately at roadside [within 4.8–5.5 dB(A)] but more accurately at the propagation side [within 0.8–2.3 dB(A)]. In the context of rail sources, experiments indicated that the CNOSSOS-EU model converged moderately with direct measurements in the context of Irish Rail vehicles [within 0.2–3.4 dB(A)] and Luas Tram Rail vehicles [within 0.3–3.9 dB(A)].

Chapter 5 outlines an assessment of past noise mapping results vis-à-vis CNOSSOS-EU whereby, compared with previous rounds of strategic noise mapping under the calculation of road traffic noise method, estimates of population exposure to road traffic noise above 55 dB(A) L_{den} (day–evening–night noise level) are expected to increase under the CNOSSOS-EU method for all local authority areas. In relation to rail sources, results indicate that estimates of population exposure to rail traffic noise above 55 dB(A) L_{den} are expected to exhibit minimal declines in the context of Luas Tram Rail and marginal increases in the context of Irish Rail under the CNOSSOS-EU method for all local authority areas in Dublin.

Chapter 6 presents a review of the assessment of industrial noise in Ireland. The majority of industrial sites in the Dublin and Cork agglomerations were reported to exceed Environmental Protection Agency (EPA) limit guidelines. However, the vast majority of such sites were still considered compliant by citing external noise rather than site activity as the reason for breaches of exceedance. Such claims are not supported by empirical evidence.

Finally, Chapter 7 outlines key recommendations for future noise mapping rounds under CNOSSOS-EU. In terms of the extent to which road sources are mapped within agglomerations, the Noise-Adapt project recommends that, in the case of South Dublin, Fingal, Dún Laoghaire–Rathdown and Cork city local authority areas, noise mapping bodies work towards including a more extensive road network in future rounds of strategic noise mapping in line with the digitally available road system in the Ordnance Survey Ireland PRIME2 dataset.

In the context of industry, where industrial sites exceed EPA limit guidelines, it is recommended that external noise sources are empirically investigated to ascertain if reported assumptions are correct. In relation to the identification and preservation of quiet areas, it is recommended that the definition of quiet areas be more clearly defined in the Environmental Noise Directive as well as in a national context, that a standardised methodology similar to, or based on, previous research should be described for the definition of quiet areas, and that such a definition be given a legal basis in legislation. In the context of limit values, it is recommended that the Environmental

1 See www.noisemapping.ie

2 Decibel(A) is an expression of the relative loudness of sounds in air as perceived by the human ear.

Noise Directive be amended to stipulate limit values for population exposure to harmful levels of noise and that national regulations be updated accordingly. Before a national ambient noise strategy can be realised, it is recommended that the role of responsibility for the strategic noise mapping process be centralised into a single responsible body in the Irish context. Finally, it is recommended that the issue of environmental noise be given greater political emphasis by the European Commission so that it is taken more seriously at the national political level and, thus, funded accordingly.

1 Introduction

1.1 Noise-Adapt

The Noise-Adapt project aims to identify Ireland's adaptation needs for transitioning to the CNOSSOS-EU (Common Noise Assessment Methods in Europe) standardised noise modelling approach and the standardised approach for population exposure estimation. In doing so, the project has reviewed existing noise mapping procedures in Ireland relative to the needs and requirements of calculation and exposure estimation under the new CNOSSOS-EU approach. Furthermore, existing policies and legislative and guidance documents have been reviewed with a view to recommending changes for new guidance associated with strategic noise mapping under CNOSSOS-EU.

The project comprised four interrelated work packages (WPs), as follows:

- WP 1 – transitioning to CNOSSOS-EU;
- WP 2 – strategic noise mapping using CNOSSOS-EU;
- WP 3 – reanalysing past strategic noise mapping data;
- WP 4 – good practice guide and final project report.

The specific objectives of the study included:

1. provision of a data needs/gaps assessment for adapting to CNOSSOS-EU in the Irish context for road and rail (WP 1);
2. assessment of CNOSSOS-EU methodology limitations that are likely to impede the successful implementation of the CNOSSOS-EU transition (WP 1);[3]
3. evaluation of the CNOSSOS-EU method within an Irish city (Dublin) and along a major road outside an agglomeration in order to assess its suitability/shortcomings for Ireland, including issues related to the point-to-point propagation under CNOSSOS-EU (WP 2);
4. exploration of the applicability of the CNOSSOS-EU method for estimating population exposure in Ireland (WP 3);
5. reassessment of past strategic noise mapping data and population exposure estimates using CNOSSOS-EU (WP 3);
6. development of practitioner guidance for future strategic noise mapping rounds using CNOSSOS-EU (WP 4);[4]
7. assessment of the suitability of existing noise policy/legislation in the light of transitioning to CNOSSOS-EU (WP 4).

The purpose of the present document is to provide a final project report that summarises the main research findings, including recommendations for future rounds of strategic noise mapping, associated with the Noise-Adapt project, funded by the Environmental Protection Agency (EPA). This document is intended to support the transition to CNOSSOS-EU approaches under the Environmental Noise Directive [END; 2002/49/EC (EU, 2002)], informed by a high-quality data analysis coupled with policy and practice recommendations to integrate and embed environmental noise pollution issues within various policy domains.

1.2 Structure of Report

Section 1.3 briefly outlines the objective of the END in the Irish context and the relevant authorities charged with implementing this objective. The rest of the report covers the following:

- Chapter 2 outlines a summary of CNOSSOS-EU transitioning needs and recommendations in relation to road sources.

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3 See *Data Needs Assessment and Recommendations for Transitioning to CNOSSOS-EU* (full report), available to download at http://www.noisemapping.ie/useful-outputs.html

4 See *Good Practice Guide for Strategic Noise Mapping and the Estimation of Population Exposure for Road and Rail Sources under CNOSSOS-EU in the Context of Ireland*, available to download at http://www.noisemapping.ie/useful-outputs.html

Table 1.1. Relevant authorities for the development of strategic noise maps in Ireland

Source	Authorities responsible
Dublin agglomeration	Dublin City Council and county councils (Dún Laoghaire–Rathdown, Fingal and South Dublin)
Cork agglomeration	Cork City Council and Cork County Council
Limerick agglomeration	Limerick City and Limerick County Council
All major railways	Irish Rail/Iarnród Éireann and Transport Infrastructure Ireland
Light tram railways (i.e. Luas)	Transport Infrastructure Ireland
National roads	Transport Infrastructure Ireland
Non-national roads	The responsible local authority of the area
Dublin Airport	Dublin Airport Authority

- Chapter 3 outlines a summary of CNOSSOS-EU transitioning needs and recommendations in relation to rail sources.
- Chapter 4 provides a summary of experiments based on the application of CNOSSOS-EU in the context of road and rail sources.
- Chapters 5 provides a summarised assessment of past noise mapping results vis-à-vis expectations under CNOSSOS-EU for road and rail sources.
- Chapter 6 outlines a review of current industry policy in Ireland.
- Chapter 7 outlines recommendations regarding future rounds of strategic noise mapping under CNOSSOS-EU and changes required to noise policy, guidance and legislation, and the implications of CNOSSOS-EU for key areas of Irish policy.
- Chapter 8 provides concluding comments on the final report document.

1.3 The Environmental Noise Directive in the Context of Ireland

The END (2002/49/EC; EU, 2002) has been a statutory instrument (S.I.) (S.I. No. 140/2006) of Irish legislation since 2006 in accordance with the Environmental Noise Regulation 2006, amended by Commission Directive (EU) 2015/996 (EU, 2015) and revoked by S.I. No. 549/2018 in accordance with the Environmental Noise Regulation 2018 (Government of Ireland, 2018). The objective of the END is to produce a standardised method for the evaluation and, ultimately, the prevention of health risks caused by population exposure to environmental noise. In order to achieve this objective, European Union (EU) Member States are obligated to perform and publish strategic noise maps (SNMs) and noise management action plans every 5 years.

The EPA is the national authority responsible for overseeing the implementation of these regulations. Where necessary, this responsibility includes oversight, instruction and co-ordination associated with SNMs performed by the relevant authorities responsible for each environmental noise source (see Table 1.1).

2 Modelling Road Sources under CNOSSOS-EU: Data Needs Assessment and Recommendations

2.1 Identify Areas to be Mapped

EU Member States have been charged with the legal obligation to produce SNMs every 5 years for all agglomerations with over 100,000 inhabitants and for all roads with over 3 million vehicle passages per annum.

2.1.1 Areas to be mapped

To ensure that road sources under investigation are accurately calculated, it important to consider input data from areas beyond the boundary of the measured sources. Such areas are referred to as the buffer zones. The Noise-Adapt project recommends that the same parameter is utilised for fetching radius and buffer zone for all local authorities within and outside agglomerations. For future rounds of strategic noise mapping within and outside agglomerations, it is recommended that the buffer zone of 1000 m be set and the fetching radius also set at 1000 m.[5] Finally, it is important to ensure that all shapefile data, particularly buildings, correspond to the respective Small Area Population Statistics (SAPS) area location within the designated local authority area in order that an accurate estimation of population based on building volume can be accomplished.

2.2 Data Collection

Primary data collection requirements for road sources include:

- annual traffic flow;
- vehicle classification under CNOSSOS-EU;
- average speed per vehicle class;
- road centrelines;
- road surface type.

Input data primarily consist of information related to annual traffic flow, as well as vehicle type and speed, and road surface. Other input data relate to building dimension, including height, terrain geometry and ground cover, as well as to barriers and bridges. In some cases, data may not be available for certain input parameters. In such cases, default input values and assumptions are acceptable "if the collection of real data is associated with disproportionately high costs" (EU, 2015; p. 5).

2.2.1 Annual traffic flow

Under the CNOSSOS-EU methodology, traffic flow data are required separately for day, evening and night periods.[6]

Within agglomerations

Within agglomerations, Dublin city, for example, uses the Sydney Coordinated Adaptive Traffic System (SCATS) to estimate the total volume of road traffic at 1100 junctions across the city, covering an area of 122 km². Total traffic volume is calculated every 15 minutes over a 24-hour period. In previous rounds of strategic noise mapping, Dublin City Council (DCC) used annual survey counts at 33 key locations across the city in order to estimate the percentage of heavy vehicles (HVs). For strategic noise mapping, average hourly values over the survey period from 07:00 to 19:00 are applied as a percentage to each hour of the SCATS data from 07:00 to 01:00 – an 18-hour period that, historically, the Calculation of Road Traffic Noise (CRTN) L10 18Hr calculations were based on. The previously utilised CRTN method was based on 18-hour traffic flows. Under the CNOSSOS-EU methodology, such estimations must be applied to a 24-hour cycle. Only Dublin city local authority area currently utilises SCATS. Cork city and county have Transport Infrastructure Ireland (TII) count data for national roads and historical count site data, which were used to supplement the round 2 (2012) traffic

5 If the model is not tiled it may be necessary to set the fetching radius to 125% of the buffer zone.

6 If data are unavailable for day/evening/night periods and/or for 24-hour cycles, consult Transport Infrastructure Ireland (TII, 2016).

data. Most, if not all, of the local authorities needed to extrapolate, gap fill and extend the actual traffic data available in order to have traffic flow data for the road network included in round 3 noise models.

Figure 2.1 illustrates how SCATS is extensive across the Dublin city local authority area. In Dún Laoghaire–Rathdown, data are available along major routes. However, in South Dublin and Fingal, SCATS is poorly represented in relative terms.

Outside agglomerations

Outside agglomerations, TII provides hourly traffic counts at 328 traffic counters for all national road networks. Data are publicly available to download from https://www.nratrafficdata.ie/c2/gmapbasic.asp?sgid=ZvyVmXU8jBt9PJE$c7UXt6 (accessed 21 January 2021). For non-national roads, traffic volume data may be estimated using field count surveys. Prospectively, it may be possible for all agglomeration local authorities to access the National Transport Model (see TII, 2019).

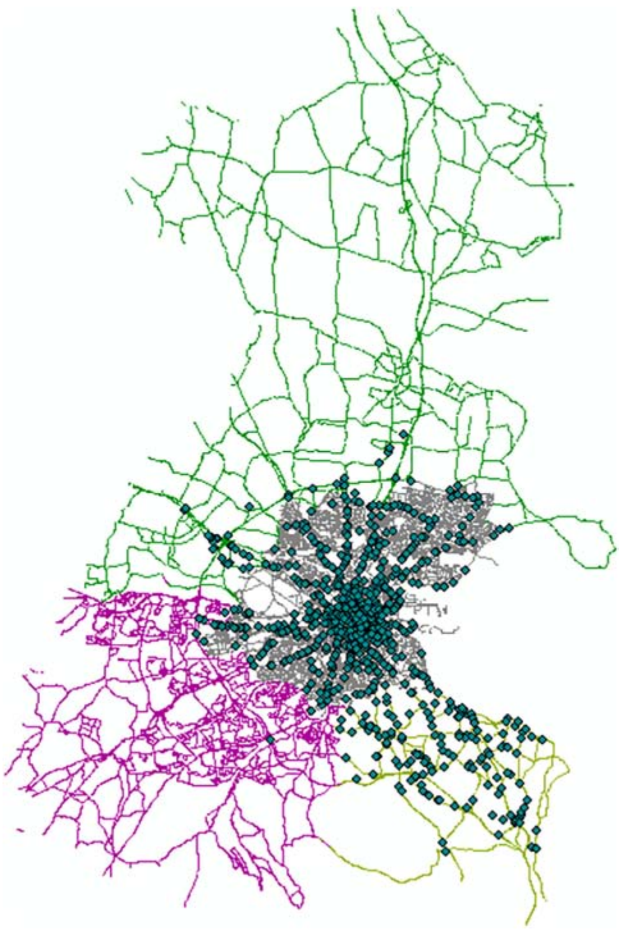

Figure 2.1. SCATS distribution across Dublin agglomeration. Road polylines are based on round 3 data supplied by local authorities. SCATS point data were acquired online from https://data.gov.ie/dataset/scats-sites-coordinates (accessed 17 May 2020).

2.2.2 Vehicle classification under CNOSSOS-EU

The UK CRTN 1998 methodology used for strategic noise mapping in Ireland from 2007 to 2017 applied two vehicle categories: one for light vehicles and one for HVs. By way of contrast, the CNOSSOS-EU methodology applies five vehicle categories. The fifth vehicle classification is prospective, as the proportion of hybrid or electric vehicles on European roads is currently insignificant.

The five vehicle classifications under CNOSSOS-EU are as follows:

1. light motor vehicles – passenger cars, delivery vans ≤ 3.5 tonnes, sport utility vehicles, multi-purpose vehicles, trailers and caravans;
2. medium HVs – delivery vans > 3.5 tonnes, buses, touring cars, etc., and vehicles with two axles and twin tyre mounting on rear axle;
3. HVs – heavy-duty vehicles, touring cars, buses, and vehicles with three or more axles;
4. powered two-wheelers – (1) mopeds, tricycles or quads ≤ 50 cc and (2) motorcycles, tricycles or quads > 50 cc;
5. open category – the development of vehicles using electric traction (either hybrid electric vehicles or totally electric). Currently there are no data available for such vehicles in Europe.

Within agglomerations

In order to categorise HVs into respective categories 2 and 3, additional and specifically tailored traffic count exercises must be conducted. In order to ascertain the priority of such an exercise, the Noise-Adapt team performed sensitivity analyses for scenarios in which the proportion of HVs was well above average in the context of Dublin city (i.e. 10% HVs). It was found that categorising HVs into various proportions (i.e. 50/50, 30/70, 70/30) and at various velocities did not significantly change the total road source emission value. For example, at a velocity of 50 km/h and 60 km/h, the estimated emission value between HVs categorised by 50/50 to 30/70 showed an average differential of just 0.3 decibel(A) [dB(A)], and those categorised by 50/50 to 70/30 showed an average differential of –0.2 dB(A), at six receiver points (see Appendix 2, Table A2.2).

> Therefore, if accurate categorisation is not possible, the Noise-Adapt project recommends that current HV flow information may be equally separated into two categories (i.e. 50/50).

This recommendation is supported by European Commission guidelines (EC, 2010; p. 39).

Regarding category 4 vehicle classification, sensitivity analyses were performed in a scenario whereby 5% of total traffic flow was represented by motorcycles. The results indicated that category 4 vehicles had a negligible effect on the total road source emission value. For example, at a velocity of 50 km/h and 60 km/h, with and without category 4 vehicles included, the results showed an average differential of just 0.1 dB(A) and 0.1 dB(A), respectively, at six receiver points (see Appendix 2, Table A2.3).

> Therefore, if data are not available for category 4 vehicles, the Noise-Adapt project recommends that this category may be excluded in the Irish context, particularly considering that category 4 vehicles represent a minimal proportion of vehicles in the Irish fleet.[7]

This recommendation is also supported by European Commission guidelines (EC, 2010; p. 39).

Outside agglomerations

Outside agglomerations, TII's vehicle classification system is based on a EURO 6 (plus motorbike) classification scheme. Vehicle classification is based on a number of factors that traffic counters are capable of measuring. These measured factors include vehicle length, chassis code and vehicle profiling. Combined, the system is commonly known as a loop profiling classifier. The system measures each factor, compares it with a preset classification table and bins the vehicle into a particular category. For the most part, classification is not based on weight; it is primarily based on length.

Currently, vehicles are categorised under the following class headings:

1. MBIKE – motorbikes;
2. CAR – passenger cars and small goods vehicles;
3. LGV – large goods vehicles;
4. BUS – buses, including minibuses;
5. HGV_RIG – heavy goods vehicles with rigid trailers;
6. HGV_ART – heavy goods vehicles with articulated trailers;
7. CARAVAN – caravans.

With this classification system there are limits on the accuracy of certain classes given the wide variety of vehicles in transit at any given time. However, the TII Strategic Transport Planning Department reports that it can supply data on national roads in line with the CNOSSOS-EU classification system.

2.2.3 Average speed

Within agglomerations

According to Commission Directive (EU) 2015/996, the average speed per vehicle category should be used in the estimation of road source emission values (EU, 2015; pp. 7–8). In the context of agglomerations, Dublin and Cork do not currently operate speed monitoring systems. In order to record average speed, a network of vehicle speed monitors would have to be installed in each agglomeration in Ireland. To ascertain the priority of such an implementation, sensitivity analyses were performed utilising a number of velocity scenarios in a case study area within Dublin city. It was found that altering the velocity of vehicles did not significantly change the total road source emission value. For example, at a velocity of 44 to 50 km/h

7 In Ireland, figures from the Central Statistics Office (CSO, 2017) describe a total of 63,474 (1.77% of total vehicle registration) new category 4 vehicles registered for the period.

and 50 to 60 km/h the estimated total emission value resulted in differentials of just 0.4 dB(A) and 0.8 dB(A), respectively, at six receiver points (see Appendix 2, Table A2.4). In this respect it must be noted that Commission Directive (EU) 2015/996 also states that “if local measurement data is unavailable the maximum legal speed for the vehicle category shall be used” (EU, 2015; p. 8).

> Therefore, in the Irish context it is considered acceptable to use the signposted speed limit within agglomerations as a measure of vehicle speed per vehicle category if average speed cannot be accurately quantified.

Outside agglomerations

Vehicle speed per vehicle is an output of the TII’s traffic monitoring unit and therefore can be easily quantified in the context of road sources on national road networks outside agglomerations.

> The Noise-Adapt project recommends that average vehicle speed per vehicle category be applied to modelling if this is possible.

Although vehicle speed data recorded by TII are not publicly accessible, they should be available on request from TII. For non-national roads it is considered acceptable to use the signposted speed limit if average speed cannot be accurately quantified.

2.2.4 Identification of traffic light and roundabout intersections within agglomerations

According to Commission Directive (EU) 2015/996 2.2.5, “before and after crossings with traffic lights and roundabouts a correction shall be applied for the effect of acceleration and deceleration” (EU, 2015; p. 11). Before such correction terms are applied, the first task for practitioners is to identify the various intersection types in each agglomeration. Such spatial identification is a particularly resource-intensive exercise, and it was therefore considered prudent to ascertain the evidence base for applying such measures. This was achieved by way of a direct measurement campaign performed at a single-lane traffic light intersection and a single-lane roundabout intersection in Dublin city in order to examine the margin of error involved in applying, and not applying, correction coefficients for each intersection type to the CNOSSOS-EU model. Results from both experiments indicated that the CNOSSOS-EU model converges closely with measurement data when the correction coefficients for traffic light and roundabout intersections are removed. For example, in relation to the traffic light intersection experiment, the results indicated that the CNOSSOS-EU model overestimated by an average of 1.5 dB(A), whereas when the correction coefficients were removed it was found that the model overestimated by an average of 0.1 dB(A) (see Chapter 4, Table 4.6). Likewise, with respect to the roundabout intersection experiment, the CNOSSOS-EU model was found to overestimate by an average of 1.5 dB(A), whereas when the correction coefficients were removed the model overestimated by 1.4 dB(A) (see Chapter 4, Table 4.8). This indicates that the level of uncertainty in how the CNOSSOS-EU coefficient correction terms estimate acceleration and deceleration in proximity to intersections may be higher than the actual effect on road traffic emission noise. Results from this experiment indicate that applying a correction coefficient model for traffic light and roundabout intersections does not improve the accuracy of results.

> Therefore, the Noise-Adapt project recommends that it is acceptable not to apply correction coefficients for traffic light and roundabout intersections at the current time, as their application does not improve the accuracy of results. These results are applicable to representative road typologies (e.g. primary roads). Results may not be applicable for unrepresentative road typologies (e.g. dead-end roads). However, the latter typology is not relevant for such application.

2.2.5 Road surface type

The current version of the CNOSSOS-EU database contains a table of 15 road surface coefficients αi, m and βm based on the Dutch road calculation method as follows (EU, 2015; pp. 126–127):

1. 0 – reference road surface;

Table 2.1. CNOSSOS-EU road surface sensitivity analysis – R108 medium to heavy traffic flow analysis LA_{eq} dB(A)

Measurement point	nl01	nl02	nl03	nl04	nl05	nl06	nl07	nl08	nl09	nl10	nl11	nl12	nl13	nl14
1	72.1	68.2	65.9	71.2	71.9	73.4	72	72.5	74.6	74	77.3	71.3	69.8	68.5
2	72.1	68.2	66	71.2	72	73.4	72	72.6	74.6	74	77.4	71.4	69.8	68.5
3	72.2	68.3	66	71.2	72	73.5	72.2	72.6	74.7	74.1	77.4	71.4	69.8	68.6
4	72.5	68.6	66.4	71.6	72.4	73.8	72.4	73	75	74.4	77.8	71.8	70.2	69

Note: shading denotes most appropriate road surface type.

2. nl01 – one-layer permeable concrete (*zeer open asfaltbeton* – zoab);
3. nl02 – two-layer zoab;
4. ni03 – two-layer zoab (fine);
5. nl04 – stone mastic asphalt (sma)-nl5;
6. nl05 – sma-nl8;
7. nl06 – brushed down concrete;
8. nl07 – optimised brushed down concrete;
9. nl08 – fine broomed concrete;
10. nl09 – worked surface;
11. nl10 – hard elements in herringbone;
12. nl11 – hard elements not in herringbone;
13. nl12 – quiet hard elements;
14. nl13 – thin layer a;
15. nl14 – thin layer b.

The Noise-Adapt project considers road surface type nl05 – sma-nl8 as most appropriate in the Irish context relative to other road types within the currently available CNOSSOS-EU database.

Table 2.1 describes a number of sensitivity analyses performed at four receiver points and based on the Dutch classification table.

These sensitivity analyses indicate that results for road surface type nl05 converge closely with those for nl01, nl04, nl06, nl07, nl08, nl10, nl12 and nl13. On the other hand, results diverge between nl05 and nl02, nl03, nl09, nl11 and nl14. Considering the data that are currently available, and which are based solely on the Dutch classification table, and considering the sensitivity analysis in Table 2.1, the Noise-Adapt project recommends that nl05 (sma-nl8) road surface types are appropriate until such a time that more specific local information becomes available. Practitioners may wish to apply Irish-specific road surface corrections, for which upcoming guidance is expected to be delivered, whereby rolling α and β values based on close proximity (CPX) measurements of road/tyre noise and statistical pass-by testing are generated. This process requires the translation of current road categories to spectral α and β coefficient octave bands and would involve applying pre-existing data that measure the interaction of physical parameters and noise emission (Olsen, 2015). TII is aiming to undertake this work for national roads in 2020/2021.

3 Modelling Rail Sources under CNOSSOS-EU: Data Needs Assessment and Recommendations

3.1 Identify Area to be Mapped

EU Member States have been charged with the legal obligation to produce SNMs every 5 years for all agglomerations with over 100,000 inhabitants and for all railways with more than 30,000 rail vehicle passages per annum.

3.1.1 Areas to be mapped

In order for rail sources under investigation to be accurately calculated it is important to consider input data from areas beyond the boundary of the measured sources. As mentioned in relation to road sources, such exterior areas are often referred to as buffer zones. The Noise-Adapt project recommends that parameters regarding fetching radius and buffer zone correspond, and that all local authorities use a standardised buffer zone and fetching radius parameter. For future rounds of strategic noise mapping, and in the context of both within agglomerations and outside agglomerations, the Noise-Adapt project recommends setting the buffer zone to a minimum of between 750 and 1000 m and also setting the fetching radius to 750–1000 m. Finally, it is important to ensure that all shapefile data, particularly buildings, correspond to the respective SAPS area location surrounding the rail sources to ensure that an accurate estimation of population based on building volume can be accomplished.

3.2 Data Collection

The primary data collection requirements for rail sources are as follows:

1. rail centreline location;
2. track transfer;
3. structure transfer;
4. rail roughness;
5. impact noise;
6. bridge constant;
7. track curvature;
8. rail vehicle type under CNOSSOS-EU;
9. vehicle length;
10. number of axles;
11. number of rail vehicles;
12. operational speed per rail vehicle;
13. running condition.

Input data primarily consist of information related to annual traffic flow, vehicle type and speed, and rail surface and type. Other input data relate to building dimension, including height, terrain geometry and ground cover, as well as to barriers and bridges. As is the case for road sources, default input values and assumptions are accepted "if the collection of real data is associated with disproportionately high costs" (EU, 2015; p. 5).

3.2.1 Track property

Track property input data are held by the infrastructural department of Irish Rail and TII (Luas Tram Rail). Such data include rail centrelines, which are determined as the midpoint between the two railheads of the source line. Physical aspects of rail tracks are assigned as attributes of the rail centreline. Where attributes alter, the rail centreline is segmented at the point of change and relevant track parameters are assigned.

Rail centreline location

Rail centrelines can be acquired from data used by TII and Irish Rail in previous rounds of strategic noise mapping and modified for any new track or track changes. Values for rail height can be generated through the integration of rail polylines onto a terrain model within a noise mapping software environment.

Track transfer

TII and Irish Rail have categorised relevant sections of track in accordance with the Dutch RMR

(*Reken- en Meetvoorschrift Railverkeerslawaai* – Railway Noise Modelling Method) standard for rail noise. Although the current version of the CNOSSOS-EU database contains varying track base types, not all are present in some noise modelling software packages. Predictor-LimA has 10 analogous track types to choose from, namely (1) empty track transfer function, (2) minimum (min), (3) maximum (max), (4) mono-block sleeper on soft rail pad, (5) mono-block sleeper on medium stiffness rail pad, (6) mono-block sleeper on hard rail pad, (7) bi-block sleeper on soft rail pad, (8) bi-block sleeper on medium stiffness rail pad, (9) bi-block sleeper on hard rail pad and (10) wooden sleeper. According to TII and Irish Rail, in the context of both the Luas Tram Rail and Irish Rail networks, ballasted track types would be most accurately represented by (6) "mono-block sleeper on hard rail pad". In the context of Luas Tram Rail, there are numerous track types that are not represented within the currently available CNOSSOS-EU database, namely embedded track and slab track. Results from a sensitivity analysis indicated that selecting parameters for "mono-block sleepers on soft rail pad" resulted in a 1–1.5 dB(A) emission increase when compared with "mono-block sleepers on hard rail pads" (see Appendix 2, Table A2.5).

> Therefore, in the absence of the required parameters within the CNOSSOS-EU model (present in the RMR model), the Noise-Adapt project recommends that, for the scenario of embedded and slab track sections, the parameter of "mono-block sleeper on soft rail pad" is selected.

Future versions of noise prediction software may include a larger updated catalogue. Additionally, TII plans to undertake research in the area of identifying and classifying track properties (namely slab and embedded track) for the Irish context in relation to the Luas Tram Rail network. This is in line with Directive 2015/996 L 168/95, which clarifies that database tables in its Appendices F to I are informative, not normative, and should be extended based on measured data where the quality criteria cannot be met with the existing datasets (EU, 2015; p. 95).

Structure transfer

Data are not currently collected for vehicle or structure transfer parameters in the Irish context. According to Thompson (2008), superstructure noise emission from rail vehicles had negligible contributions in terms of wayside noise when compared with the dominant source at the wheel/rail region. Sensitivity analyses also determined that, apart from imputation of the "maximum" parameter within the noise prediction software, all other parameters were found to produce identical rail source emission results (see Appendix 2, Table A2.6). Therefore, it may not be considered beneficial to conduct the necessary surveys in order to ascertain structure transfer parameters in the Irish context unless desired.

> For the present time, the Noise-Adapt project recommends that the "CNOSSOS-EU default" parameter is used with respect to structure transfer.

Rail roughness

As stated by the European Commission Working Group Assessment of Exposure to Noise (WG-AEN) "The difference in sound emission from well-maintained rails and wheels to similar but poorly maintained rails can be 10 dB or more. Consequently, it is of great importance to establish and use the correct data on rail conditions" (WG-AEN, 2007). In relation to rail roughness, the currently available CNOSSOS-EU database consists of five parameters: (1) empty rail roughness, (2) min, (3) max, (4) EN ISO (International Organization for Standardization) 3095:2013 and (5) average network. Sensitivity analysis demonstrated that the "average network" rail roughness parameter is 1.5 dB(A) higher than the EN ISO 3095:2013 parameter (see Appendix 2, Table A2.7). The most accurate approach in the allocation of rail roughness values for modelling is to conduct experiments to best capture track roughness for various sections of track. In the absence of these data, the Noise-Adapt project recommends that the "average network" parameter be selected, as it is most representative of the Irish Rail network. However, this parameter may not be suitable for particular track sections and, thus, alternative parameters may need to be applied where appropriate (e.g. in sections where roughness is known to be particularly problematic). In the context of the Luas Tram Rail network, periodic corrugation surveys have shown the default upper limit curve for rail roughness within EN ISO 3095:2013 to be well exceeded in a number of locations. Therefore, in such cases it may be necessary to create a custom rail roughness parameter for use within the XML (extensible markup language) rail track catalogue in the context of the Luas Tram Rail network in line with Directive 2015/996 (EU, 2015; p. 95).

Impact noise

Information regarding the location of impact noise generated from vehicles passing over crossings, switches and rail joints may be obtained from TII and Irish Rail databases. This is a new requirement under CNOSSOS-EU. The presence of a single crossing, switch or joint can be the most dominant contribution to rolling noise, as has been observed through sensitivity analysis using noise prediction software (see Appendix 2, Table A2.8). The noise prediction software package offers four parameters, namely (1) empty impact noise, (2) min, (3) max and (4) single switch/joint/crossing/100 m. It should be noted that the CNOSSOS-EU model provides an additional rail roughness element based on joint density per length of track. It is possible to account for the additional number of discontinuities per 100 m by the addition of $10^{\log(n)}$, where n is the number of discontinuities, at all wavelengths to the database default spectrum "single switch/joint/crossing/100 m" (Paviotti *et al.*, 2015). This can be achieved by modifying the default rail track XML catalogue or by adhering to the recommendation outlined in Paviotti *et al.*'s impact noise look-up table. This table describes how sections of track with jointless rails should be allocated the parameter of "min". For sections of track with one or two joints or discontinuities per 100 m the parameter for "single switch/joint/crossing/100 m" is recommended, whereas for sections of track with more than two joints or discontinuities per 100 m the "max" value is recommended (see Paviotti *et al.*, 2015). Finally, it should be noted that future software updates may be provided to allow better usability of this parameter.

Bridge constant

Information regarding bridge type and location may be obtained from TII and Irish Rail databases. The CNOSSOS-EU database offers five categories for bridge constant, namely (1) empty bridge constant, (2) min, (3) max, (4) predominantly concrete or masonry bridges with any track form and (5) predominantly steel bridges with ballasted track.

> For the Irish context the Noise-Adapt project recommends inputting the relevant bridge constant where applicable with classification data acquired from the aforementioned datasets. For the majority of rail track where no bridge is present, the "empty bridge constant" category should be applied.

Track curvature

The CNOSSOS-EU method recommends the application of 8 dB(A) for a track curve radius less than 300 m, and 5 dB(A) for a track curve radius of between 300 and 500 m. This is a new requirement under CNOSSOS-EU. Track squeal tends to arise predominantly when both wheels and rails are dry, but not when wet. However, the current CNOSSOS-EU corrections assume that every rail vehicle across the whole year will squeal in the same place, which is very unlikely to be the case.

> In view of the situation, the Noise-Adapt project recommends that this is investigated further by Irish Rail where a track curve radius less than 500 m is present.

The application of the 8 dB(A) and 5 dB(A) (flat spectrum) refers to heavy rail only. In the context of Luas Tram Rail, vehicles use onboard lubrication systems to mitigate squeal emission. Additionally, trams tend to squeal only in curves with radii that are much less than for heavy rail (Verheijen and van Beek, 2019). As recommended in Verheijen *et al.* (2019), a more suitable application of squeal for light rail vehicles would be a 5 dB(A) (flat spectrum) penalty applied to track curves with radii less than 200 m, and no squeal penalty applied to a track curve with radii greater than 200 m. It has been noted that, for the case of the Luas Tram Rail network, the presence of squeal owing to the curve radius of track section is an issue only on some curved track sections, whereas other curved track sections of the same radius have been observed to exhibit no additional noise owing to squeal. This can possibly be attributed to variations in track design and construction methods implemented over the Red and Green line networks. On account of this phenomenon, and the limited number of curves across the Luas Tram Rail network, it is deemed practicable to undertake direct measurements and compile site-specific data relating to the contribution of squeal to rail source emission.

3.2.2 Vehicle properties

Data regarding vehicle property values can be obtained from respective train operators in Irish Rail and TII (Luas Tram Rail). In relation to this, vehicle movements are required to be assigned to respective sections of track. The number of vehicle movements is required per vehicle category, and annual average hourly information is required per time period for the following: L_{day}, $L_{evening}$, L_{night} and L_{den}. For each vehicle category and time period, operation vehicle speed over each section of track must also be ascertained. The number of vehicle carriages and vehicle operating conditions (i.e. constant speed or idling) must also be determined. Such information may be acquired from train timetables, train network modelling systems and/or trackside train sensing systems. The CNOSSOS-EU database currently contains a limited set of vehicle categories. Different software packages, such as Predictor-LimA, have expanded the CNOSSOS-EU calculation method database to include converted previous RMR classification.

However, as these unverified converted classification categories may not accurately equate with vehicles operating within the Irish fleet, the Noise-Adapt project recommends that a review be conducted and a modified analogous rail vehicle XML catalogue be created to best represent the Irish fleet in its entirety.

It has been noted that TII plans to undertake testing of the Irish fleet in 2020/21. Various European Committee for Standardization (CEN) standards are being developed in an effort to create harmonised methods for the measurement and classification of rail vehicles; some include EN ISO 3095:2013 and EN 15610:2019.

With this in mind, it was outlined in a letter report from the Dutch National Institute for Public Health and the Environment in 2019 (Kok and van Beek, 2019) that the European Commission will take the initiative in creating guidance documents in response to a lack of vehicle type database information under the CNOSSOS-EU methodology.

Rail vehicle type under CNOSSOS-EU

Directive (EU) 2015/996 L 168/12 (EU, 2015; p. 12) states that a vehicle is defined as “any single railway sub-unit of a train (typically a locomotive, a self-propelled coach, a hauled coach or a freight wagon) that can be moved independently and can be detached from the rest of the train”. However, in the case of vehicle subunits that are part of a non-detachable set (e.g. which share a single bogie) should be grouped as a single vehicle for the purpose of calculation. It must be emphasised that descriptors are defined as, and correspond to, the properties of respective vehicles. This affects the acoustic directional sound power per metre length of the equivalent source line modelled. Previously, Ireland used the RMR train classification to map the Irish fleet for suitable model conditions. Table 3.1 outlines potential vehicle identification and categorisation for both RMR and the new categories currently available in software with respect to the Irish fleet.

CNOSSOS-EU classification has allowed for further granularity in relation to the newly split categories for diesel multiple units (DMUs) and InterCity Railcars (ICRs) with respect to the Irish Rail fleet. The noise prediction software allocates preset values for

Table 3.1. Rail vehicle type CNOSSOS-EU/RMR-1996

Irish fleet	Predictor rail category	SNM Round 1–3 RMR train category
DART EMUs	10	8
DMUs	8	6
ICRs	19	6
Mk4s	14	3
Freight	15	4
Luas Tram	20	7

DART, Dublin Area Rapid Transit; DMU, diesel multiple unit; EMU, electric multiple unit; ICR, InterCity Railcar; Mk4, Mark IV InterCity train.

each vehicle type, whereby further customisation (e.g. number of axles, length of vehicle) is possible through the modification of catalogue XML files for both rail vehicle and track. For each of the 20 vehicle classifications within the noise prediction software database, it is possible to modify the following descriptors and parameters within the vehicle XML catalogue file:

1. ID = unique identification of the vehicle;
2. Code = vehicle code short description (informative);
3. Description = vehicle type long description (informative);
4. P_mech = power in kilowatts (informative);
5. V_max = max speed in kilometres per hour (informative);
6. Weight = weight in tonnes (informative);
7. Length = length in metres;
8. Axles = number of axles;
9. WheelDiameter = in millimetres (informative);
10. WheelDiameterCode = diameter in millimetres (large, medium, small) (informative);
11. WheelMeasure = wheel measures (none, wheelDampers, screens, other) (informative);
12. BrakeCode = brake type (castIronBlock, compositeBlock, disk) (informative);
13. Load = load in kilonewton (informative);
14. RefTransfer = reference to table “VehicleTransfer”;
15. RefContact = reference to table “ContactFilter”;
16. RefRoughness = reference to table “WheelRoughness”;
17. RefTraction = reference to table “TractionNoise”;
18. RefAerodynamic = reference to table “AeroDynamicNoise”.

> Although analogous settings for train types are available within the software default vehicle XML catalogue (automatically generated when a new model is created), the Noise-Adapt project recommends that a modified rail vehicle XML catalogue is created to better represent the Irish fleet in its entirety.

The parameters required to be tuned for each vehicle classification include vehicle type, number of axles per vehicle, brake type and wheel measure. To acquire these data, it may be necessary to undertake direct measurement campaigns for the varying rolling stock within the Irish context. Efforts are being made by working group CEN/TC 256/WG3[8] to create harmonised standards that outline appropriate measurement methods that can be used to more accurately categorise vehicle types. With the modified XML catalogue imputed, vehicle types found in the CNOSSOS-EU database corresponding to vehicles in the Irish fleet should be selected, as outlined in Table 3.1. With respect to Luas Tram Rail, the Noise-Adapt project recommends creating two categories so that the Citadis 401/402 trams (length = 45 m) and the Citadis 502 trams (length = 55 m) are represented separately.

Vehicle length

The average rail vehicle length per category should be imputed into the CNOSSOS-EU modified vehicle XML catalogue under the relevant classification categories. In the context of Luas Tram Rail, a second category identical to category 20 should be created to mirror all the values except the train length and number of axles. This should be completed in order to correctly model the Citadis 401/402 tram (length = 45 m/ axles = 8) relative to the Citadis 502 tram (length = 55m/ axles = 10).

Number of axles

As mentioned previously, the number of axles per vehicle should be imputed to the CNOSSOS-EU modified vehicle XML catalogue under the relevant classification categories.

8 Non-exclusive relevant standards within WG3; EN 15610:2019 – Rail and wheel roughness measurement related to noise generation; EN ISO 3095:2013 – Measurement of noise emitted by rail-bound vehicles.

Number of rail vehicles

The number of vehicle types should be imputed for each respective track section, for each time period and on an annual average basis (i.e. L_{day}, $L_{evening}$, L_{night} and L_{den}). The noise prediction software implementation of the CNOSSOS-EU model stipulates hourly average number of vehicles of each type. This information can be obtained from timetable data provided by train operators from Irish Rail and TII.

Operation speed per rail vehicle

Average vehicle speed measured as kilometre per hour should be imputed for each vehicle type, for each track section, for each time period and on an annual average basis (i.e. L_{day}, $L_{evening}$, L_{night} and L_{den}). These data can be obtained from respective train operators from Irish Rail and TII, as well as from datasets used for previous rounds of strategic noise mapping.

Running condition

Parameters associated with running condition within the noise prediction software currently include (1) constant speed, (2) accelerating, (3) decelerating and (4) idling. However, it should be noted that Commission Directive (EU) 2015/996 L 168/21 (EU, 2015; p. 21) accounts only for parameter inputs relating to constant speed or idling.

> The Noise-Adapt project recommends that the relevant running condition (i.e. constant speed or idling) is applied to all modelled vehicles per section of track in the Irish fleet.

Round 3 SNM railway shapefile data for running condition and operating speed per vehicle per section of track have sufficient resolution at present.

4 Application of the CNOSSOS-EU Approach[9]

4.1 Application of CNOSSOS-EU in the Context of Road Sources within an Agglomeration

In order to evaluate the predictive ability of the CNOSSOS-EU method in the context of road sources within Irish agglomerations, an experimental analysis was carried out. The analysis comprised a direct measurement campaign at locations representative of four traffic flow scenarios relevant to the new CNOSSOS-EU methodology. These were:

- scenario 1: high to medium traffic flow;
- scenario 2: low to medium traffic flow;
- scenario 3: traffic light intersection traffic flow;
- scenario 4: roundabout intersection traffic flow.

4.1.1 Methodology

The decision for a controlled case study location was primarily based on the location of DCC's ambient sound monitoring network. This network continuously measures long-term environmental noise at 14 sites across the city. In order to determine the most appropriate site for the controlled case study location, DCC's *Ambient Sound Monitoring Network Annual Report 2018* (DCC, 2018) was scrutinised. Unstable sound levels were reported at more traditionally quiet areas such as Chapelizod Road, Woodstock Gardens, Bull Island, Ringsend and Blessington Basin. Of the remaining sites, the Ballymun Library site exhibited the most regular diurnal trends and was therefore deemed the most suitable location for controlled case study analysis.

Microphones were positioned 7.5 m from the centre of the measured lane in accordance with ISO 11819-1, at a ground-level height of 1.5 m in accordance with ISO 1996-2:2017/BS 7445-1:2003,[10] and at intervals of 30 m in accordance with ISO 18819-1, whereby microphone positions are recommended to extend 30 m on either side of the road section. In the context of propagation analysis, two microphones were positioned 30 m from the centre of the measured lane at a ground-level height of 1.5 and 4 m, respectively. These two microphones were positioned to assess the effect of the attenuation of noise due to propagation, with the 4 m ground-level height microphone reflecting the fact that receivers are placed at a ground-level height of 4 m at the façade of buildings in noise prediction calculation under CNOSSOS-EU.

4.1.2 Results

Scenario 1: high to medium traffic flow

The experiment was conducted on 20 February 2019 for the duration of 1 hour between 15:15 and 16:15 on a weekday afternoon. Direct measurement took place using Type 1 sound level meters (SLMs) positioned at 10 locations on either side of the R108 three-lane dual carriageway, one Type 2 meter (i.e. Sonitus System) at one location, and low-cost sensors (LCSs) located at six locations (see Figure 4.1 and Table 4.1). In the context of propagation analysis, microphones were placed at a distance of 30 m from the centre of the measured lane. A mobile weather station kit was utilised in order to record wind speed, temperature, atmospheric pressure and humidity. Traffic count per vehicle category was recorded using video recording equipment, whereas average speed per vehicle category was captured using a handheld speed monitoring device.

Table 4.1 describes the composition of traffic flow during the 1-hour period of direct measurement in accordance with respective CNOSSOS-EU vehicle categorisation, velocity and meteorological conditions.

9 Results for all models were generated using Predictor-LimA version 2020.1.

10 See also NRA (2014). Similar studies have measured road traffic noise using microphones positioned at 1.5 m ground-level height (e.g. Iannone *et al*., 2013; Gulliver *et al*., 2015; Herisanu and Marinca, 2018), while others have applied microphones at 1.2 m ground-level height (e.g. Suksaard *et al*., 1999; Cai *et al*., 2015). A CNOSSOS-EU model applying receivers at six points 7.5 m from the centre of the measured lane generated no differentials between receivers placed at 1.5 m and 1.2 m ground-level height in a medium to heavy traffic flow scenario.

Figure 4.1. High to medium traffic flow experimental set-up. Maps data: Google © 2019.

Table 4.1. R108 medium to heavy traffic flow composition and meteorological conditions

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
West lane			Temperature: 14.98°C, 288.13 K Pressure: 101.5 kPa Air humidity: 59.07% Wind speed: <2 m/s Wind direction: south-west Ground condition: dry Cloud cover: partial
Category 1	952	43	
Category 2	19	43	
Category 3	9	34	
Category 4a	2	56	
East lane			
Category 1	808	42	
Category 2	55	41	
Category 3	7	35	
Category 4a	2	40	

Table 4.2 presents direct measurement results relative to estimated results generated by the CNOSSOS-EU model calculated using noise prediction software. Round 3 data supplied by DCC were utilised in the generation of the CNOSSOS-EU model. Building height, building reflection factor (i.e. 0.8), ground absorption factor (i.e. $G=0.7$) and height line data were applied in accordance with this dataset. CNOSSOS-EU road surface typology was based on the currently available Dutch classification SMA-NL8 (i.e. R-n105-sma-nl8).[11]

Application of CNOSSOS-EU vis-à-vis roadside measurements

- Roadside direct measurements (i.e. microphones positioned 7.5 m from the centre of the measured lane) recorded an average road source emission value of 74.0 dB(A) on the west lane and 72.7 dB(A) on the east lane of the R108.
- The CNOSSOS-EU model estimated an average road source emission value of 72.1 dB(A) on the west lane and 72.0 dB(A) on the east lane of the R108, underestimating by an average of –1.9 dB(A) and –0.6 dB(A), respectively.

11 DCC reports that hot rolled asphalt (HRA) is predominantly used as road surface material in Dublin agglomeration, with SMA containing a maximum of 10 mm stones (SMA-10) and SMA-15 used in certain areas. DCC maintains that the use and laying of road surface in the Dublin agglomeration is in line with national standards as prescribed by TII. Dutch classification SMA-NL8 is the closest road surface type to HRA, SMA-10 and SMA-14 available at the current time.

Table 4.2. Direct measurement vis-à-vis CNOSSOS-EU model results – R108 traffic flow analysis LA_{eq} dB(A)

Microphone location	Microphone height (m)	SLM	Sonitus System [dB(A)]	LCS [dB(A)]	CNOSSOS-EU model [dB(A)]	Differential [dB(A)]
West lane						
1	1.5	73.9	73.5	75.8	71.9	–2.0
2	1.5	73.8	–	73.8	72.0	–1.8
3	1.5	73.9	–	–	72.0	–1.9
4	1.5	74.4	–	72.0	72.4	–2.0
East lane						
5	1.5	72.6	–	–	71.9	–0.7
6	1.5	72.8	–	–	71.9	–0.9
7	1.5	72.6	–	–	71.9	–0.7
8	1.5	72.6	–	76.6	72.4	–0.2
Propagation						
9 (30 m)	1.5	64.8	–	76.4	65.9	1.1
10 (30 m)	4	66.3	–	–	65.7	–0.6

–, no data.

Application of CNOSSOS-EU vis-à-vis propagation measurements

- Direct measurement at a distance of 30 m from the centre of the measured lane positioned at a ground-level height of 1.5 and 4 m recorded an emission value of 64.8 dB(A) and 66.3 dB(A), respectively.
- At a distance of 30 m from the centre of the measured lane and at a ground-level height of 1.5 and 4 m, the CNOSSOS-EU model estimated an average road source emission value of 65.9 dB(A) and 65.7 dB(A), respectively, overestimating by 1.1 dB(A) and underestimating by –0.6 dB(A), respectively.

Conclusion

- In relation to medium to high traffic flow within an agglomeration and in the Irish context, the predicted results generated from a CNOSSOS-EU model converge closely with direct measurements [i.e. 0.2–2 dB(A)].

Scenario 2: low to medium traffic flow

A low to medium traffic flow experiment was conducted on 21 February 2019 for the duration of 1 hour between 13:00 and 14:00 on a weekday. Direct measurement took place using Type 1 SLMs positioned at four locations and LCSs located at two locations on the southern perimeter of a two-lane single carriageway. Microphones were positioned 7.5 m from the centre of the measured lane at a ground-level height of 1.5 m and at intervals of 30 m. Road surface typology was based on the currently available Dutch classification SMA-NL8 (i.e. R-n105-sma-nl8). Metrological information, traffic count and average speed were recorded as previously described. Table 4.3 describes the composition of traffic flow during the 1-hour period of direct measurement in accordance with respective CNOSSOS-EU vehicle categorisation and in respect to velocity accorded to each vehicle category.

Table 4.4 presents direct measurement results relative to estimated results generated by the CNOSSOS-EU model. Round 3 data supplied by DCC were utilised in the generation of the CNOSSOS-EU model with the parameters described previously.

Results

- Roadside direct measurements recorded an average road source emission value of 69.7 dB(A).
- The CNOSSOS-EU model estimated an average road source emission value of 70.0 dB(A), overestimating by an average of 0.3 dB(A).

Table 4.3. R103 low to medium traffic flow traffic composition and meteorological conditions

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 1	600	50	Temperature: 16.10°C, 289.25K
Category 2	13	50	Pressure: 101.42kPa
Category 3	10	49	Air humidity: 57.32%
Category 4a	7	51	Wind speed: <2m/s
			Wind direction: south-west
			Ground condition: dry
			Cloud cover: partial to clear

Table 4.4. CNOSSOS-EU model validation results – R103 low to medium traffic flow analysis LA_{eq} dB(A)

Microphone location	SLM	LCS	CNOSSOS-EU model	Differential
1	69.5		69.9	0.4
2	69.8	53.1	70.0	0.2
3	69.4		70.0	0.6
4	70.1	56.5	70.0	–0.1

Conclusion

- In the context of low to medium traffic flow within an agglomeration and in the Irish context, the predicted results generated from a CNOSSOS-EU model converged closely with direct measurements [i.e. 0.1–0.6dB(A)].

Scenario 3: traffic light intersection traffic flow

In order to evaluate the impact of acceleration and deceleration of traffic in the proximity to intersections under CNOSSOS-EU, a direct measurement campaign was conducted in the context of a traffic light intersection in the Ballymun case study location. The experiment took place on 21 February 2019 for the duration of 1 hour between 14:30 and 15:30 on a weekday afternoon (see Figure 4.2). Direct measurement took place using Type 1 SLMs positioned at four locations on the northern perimeter of a two-lane single carriageway. Microphones were positioned and road surface typology was applied as previously described. Metrological information, traffic count and average speed were recorded as previously described.

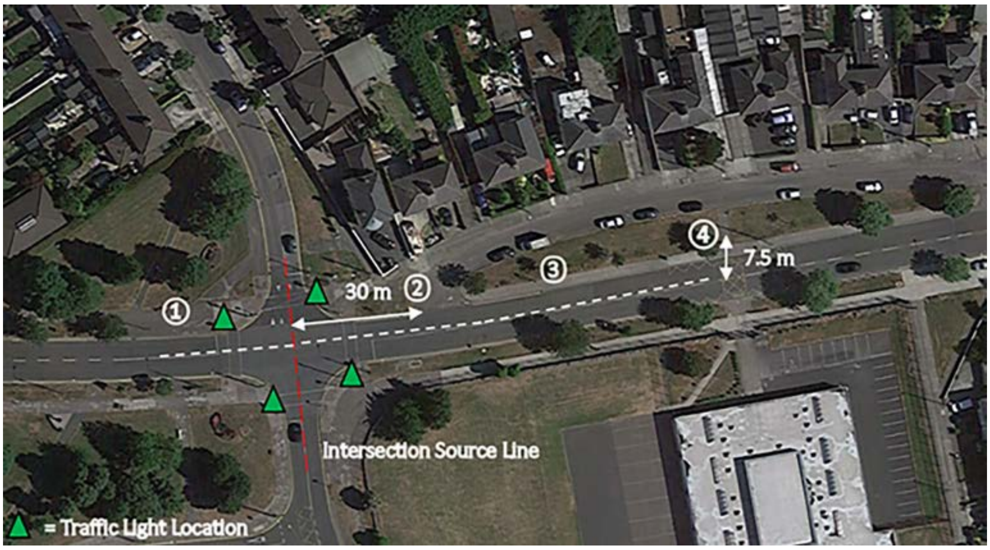

Figure 4.2. Traffic light intersection experimental set-up. Maps data: Google © 2019.

Table 4.5 describes the composition of traffic flow during the 1-hour period of direct measurement in accordance with respective CNOSSOS-EU vehicle categorisation, velocity and meteorological conditions.

Table 4.6 presents direct measurement results relative to estimated results generated by the CNOSSOS-EU model when the correction coefficients are applied and when not applied. Round 3 data supplied by DCC were utilised in the generation of the CNOSSOS-EU model with parameters previously described.

Results

- Roadside direct measurements recorded an average road source emission value of 68.5 dB(A).
- The CNOSSOS-EU model estimated an average road source emission value of 70 dB(A) when traffic light correction coefficients were applied, overestimating by an average of 1.5 dB(A).
- The CNOSSOS-EU model estimated an average road source emission value of 68.5 dB(A) when the traffic light correction coefficients were removed, overestimating by an average of 0.1 dB(A).

Conclusion

- Results from this experiment indicate that applying a correction coefficient model for traffic light intersections does not improve the accuracy of results. Therefore, the Noise-Adapt project considers that it is acceptable not to apply correction coefficients for traffic light intersections at the current time, as their application does not improve the accuracy of results. These results are applicable to representative road typologies (e.g. primary roads). Results may not be applicable for unrepresentative road typologies (e.g. dead-end roads). However, the latter typology is not relevant for such application.

Scenario 4: roundabout intersection traffic flow

To evaluate the impact of acceleration and deceleration in proximity to intersections under CNOSSOS-EU, a direct measurement campaign was conducted in the proximity of a roundabout intersection in the Ballymun case study location. The experiment took place on 21 February 2019 for the duration of 1 hour between 13:00 and 14:00 on a weekday (see Figure 4.3). Direct measurement took place using Type 1 SLMs positioned at four locations on the southern perimeter of a two-lane single carriageway. Microphones were positioned and road surface typology was applied as previously described. Metrological information, traffic count and average speed were recorded as previously described.

Table 4.5. R103 light intersection traffic composition and meteorological conditions

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 1	707	29	Temperature: 14.98°C, 288.13 K
Category 2	28	27	Pressure: 101.5 kPa
Category 3	4	28	Air humidity: 59.67%
Category 4a	2	28	Wind speed: < 2 m/s
			Wind direction: south-west
			Ground condition: dry
			Cloud cover: partial to clear

Table 4.6. CNOSSOS-EU model validation – R103 traffic light intersection analysis LA_{eq} dB(A)

Microphone location	Distance from intersection (m)	SLM [dB(A)]	Correction coefficient [dB(A)]		Differential [dB(A)]	
			Applied	Not applied	Applied	Not applied
1	30	67.8	71.1	68.8	3.3	1.0
2	30	68.1	71.2	68.9	3.1	0.8
3	60	68.7	69.2	68.2	0.5	–0.5
4	90	69.3	68.3	68.2	–1.0	–1.1

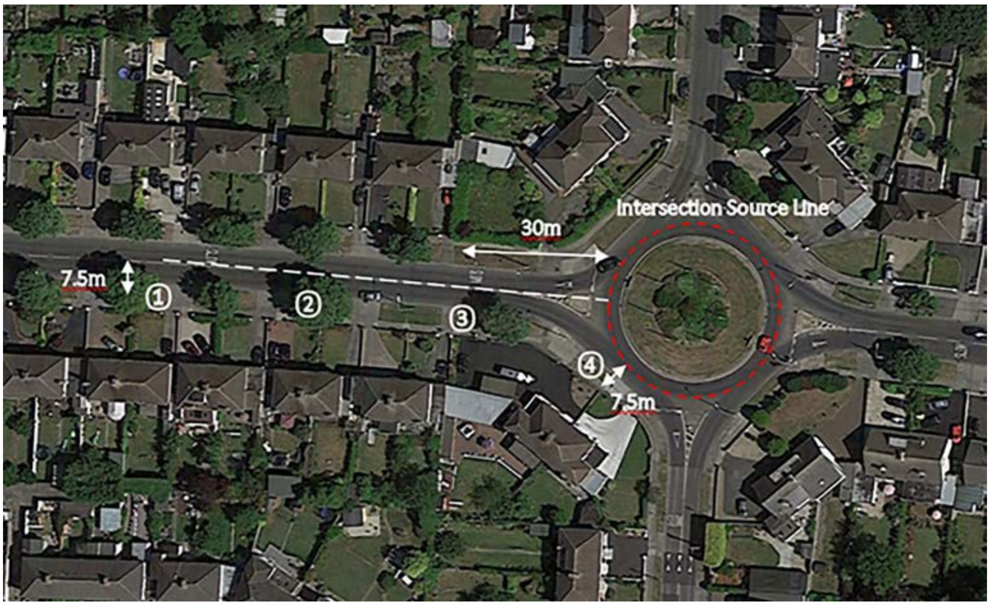

Figure 4.3. Roundabout intersection experimental set-up. Maps data: Google © 2019.

Table 4.7 describes the composition of traffic flow during the 1-hour period of direct measurement in accordance with respective CNOSSOS-EU vehicle categorisation, velocity and meteorological conditions.

Table 4.8 outlines direct measurement results relative to estimated results generated by the CNOSSOS-EU model when the intersection correction coefficient effect is applied and removed. Round 3 data supplied by DCC were utilised in the generation of the CNOSSOS-EU model with parameters previously described.

Results

- Roadside direct measurements recorded an average road source emission value of 67.1 dB(A).
- The CNOSSOS-EU model estimated an average road source emission value of 68.8 dB(A) when

Table 4.7. Roundabout intersection traffic composition and meteorological conditions

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 1	600	40	Temperature: 16.10°C, 289.25 K
Category 2	13	39	Pressure: 101.42 kPa
Category 3	10	39	Air humidity: 57.32%
Category 4a	7	40	Wind speed: < 2 m/s
			Wind direction: south-west
			Ground condition: dry
			Cloud cover: partial to clear

Table 4.8. CNOSSOS-EU model validation – R103 roundabout intersection analysis LA_{eq} dB(A)

Location	Distance from intersection (m)	SLM	Correction coefficient		Differential	
			Applied	Not applied	Applied	Not applied
1	90	69.5	68.9	69.0	–0.6	–0.5
2	60	68.2	68.6	68.8	0.4	0.6
3	30	66.1	68.4	68.1	2.3	2.0
4	7.5	64.7	69.1	68.2	4.4	3.5

the roundabout correction coefficient was applied, overestimating by an average of 1.6 dB(A).
- The CNOSSOS-EU model estimated an average road source emission value of 68.5 dB(A) when the roundabout correction coefficient was removed, overestimating by an average of 1.4 dB(A).

Conclusion

- Results from this experiment indicate that applying a correction coefficient model for roundabout intersections does not improve the accuracy of results. Therefore, the Noise-Adapt project considers that it is acceptable not to apply correction coefficients for roundabout intersections at the current time, as their application does not improve the accuracy of results. These results are applicable to representative road typologies (e.g. primary roads). Results may not be applicable for unrepresentative road typologies (e.g. dead-end roads). However, the latter typology is not relevant for such application.

4.2 Application of CNOSSOS-EU in the Context of Road Sources outside an Agglomeration

In order to evaluate the suitability of the CNOSSOS-EU method in the context of road sources outside an agglomeration, an experimental analysis took place by way of a direct measurement campaign at a location representative of a major road network with more than 3 million passages per annum.

4.2.1 Methodology

The choice of a controlled case study location was initially based on the location of TII's network of traffic count units, of which there are 328 nationwide. Performing the experiment in close proximity to such traffic counters permitted a cross-validation of traffic count, general vehicle categorisation and average vehicle speed data. Another primary concern in determining a case study location related to accessibility and the ability to position microphones in close proximity to respective road sources. In this regard, several sites were investigated in order to ascertain suitability for experimental analysis.

Microphones were to be positioned 7.5 m from the centre of the measured lane in accordance with ISO 11819-1. However, this parameter was not possible because of terrain issues (i.e. microphones could not be placed this close to the centre of the measured lane owing to obstructions). Such issues were common in all prospective case study sites selected at the time of analysis. Therefore, roadside microphones were placed at 15 and 9 m (see Table 4.10). All microphones were placed at a source level height of 1.5 m in accordance with ISO 1996-2:2017/BS 7445-1:2003. In the context of propagation analysis, one microphone was positioned 50 m from the centre of the measured lane.

4.2.2 Results

The experiment was conducted on 26 March 2019 for the duration of 1 hour on a weekday morning between 10:45 and 11:45 (Figure 4.4). Metrological information, traffic count and average speed were recorded as previously described.

Table 4.9 describes the composition of traffic flow during the 1-hour period of direct measurement in accordance with respective CNOSSOS-EU vehicle categorisation, velocity and meteorological conditions.

Table 4.10 describes the CNOSSOS-EU model results in the context of medium to high traffic flow on a major road outside an agglomeration (i.e. greater than 3 million passages per annum). The table presents the direct measurement results recorded using Type 1 SLMs at four locations on the western perimeter of a two-lane dual carriageway. Data supplied by TII were utilised in the generation of the CNOSSOS-EU model. The ground absorption factor was set to 0.7 and height line data were applied in accordance with data provided by TII. Road surface typology was based on the currently available Dutch classification SMA-NL8 (i.e. R-n105-sma-nl8).[12]

12 TII reports that hot rolled asphalt (HRA) is predominantly used as road surface material in national and regional road networks outside agglomerations, with SMA-10 and SMA-15 used in certain areas. Dutch classification SMA-NL8 is the closest road surface type to HRA, SMA-10 and SMA-14 available at the current time.

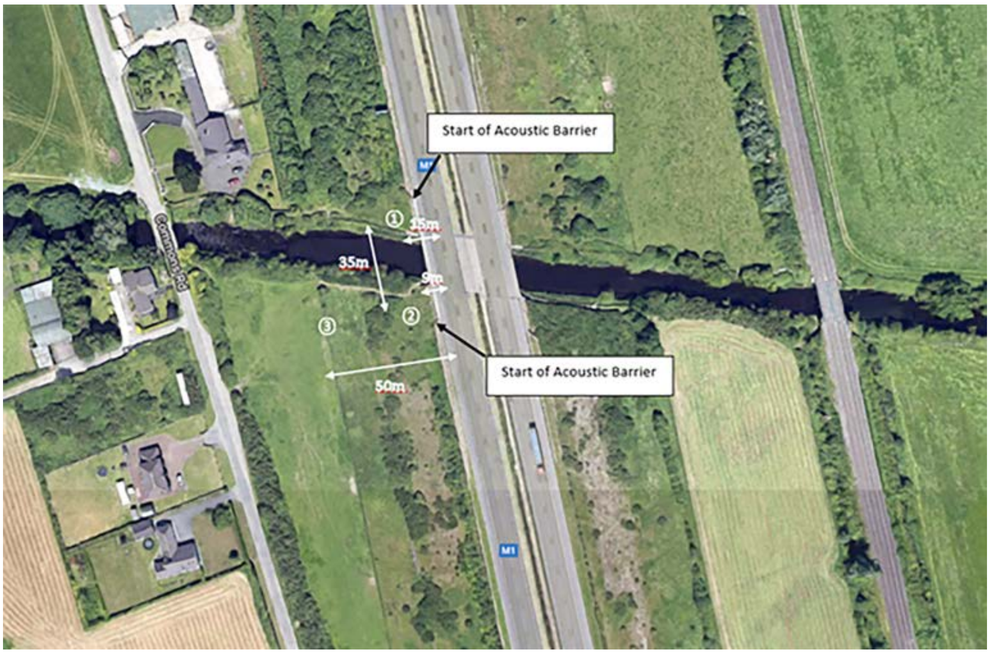

Figure 4.4. Experimental set-up for validation outside an agglomeration. Maps data: Google © 2019.

Table 4.9. M1 Motorway medium to heavy traffic composition and meteorological conditions

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 1	643	122	• Temperature: 12.71°C, 285.86K
Category 2	30	101	• Pressure: 103.52kPa
Category 3	137	90	• Air humidity: 58.93%
Category 4a	0	0	• Wind speed: <2m/s
			• Wind direction: south, south-east
			• Ground condition: dry
			• Cloud cover: partial to complete

Table 4.10. CNOSSOS-EU model validation – M1 Motorway analysis LA_{eq} dB(A)

Location	SLM	CNOSSOS-EU model	Differential
1	79.4	74.1	–5.3
2	82.3	76.8	–5.5
Propagation			
3 (50m)	62.1	61.3	–0.8

Application of CNOSSOS-EU vis-à-vis roadside measurements

- Roadside direct measurements (i.e. at 15 and 9m, respectively) recorded an average road source emission value of 80.9dB(A).
- The CNOSSOS-EU model estimated an average emission value of 75.5dB(A), underestimating by an average of –5.4dB(A).

Application of CNOSSOS-EU vis-à-vis propagation measurements

- Direct measurement at a distance of 50m from the centre of the measured lane recorded an emission value of 62.1dB(A).
- At a distance of 50m from the centre of the measured lane, the CNOSSOS-EU model estimated an emission value of 61.3dB(A), underestimating by –0.8dB(A).

Conclusion

- The CNOSSOS-EU model estimated less accurately at roadside (i.e. 15 m/9 m from the centre of the measured lane) but more accurately in terms of propagation (i.e. at 50 m from the centre of the measured lane). In respect to the former, the CNOSSOS-EU model did not converge closely with direct measurements [i.e. 5.3–5.5 dB(A)]; in respect to the latter, the CNOSSOS-EU model did converge closely [i.e. 0.8 dB(A)].

Hard ground propagation analysis – Hunterstown (N2)

In order to evaluate the suitability of the CNOSSOS-EU method in the context of road sources outside an agglomeration, an experimental analysis took place at an alternative location whereby microphones were unobstructed. Owing to differences found in accuracy between the CNOSSOS-EU source model and the CNOSSOS-EU propagation model illustrated in the previous experiment, microphones were positioned to assess the effect of the attenuation of noise due to propagation. A direct measurement campaign took place on a continuously hard ground surface (i.e. $G = 1$) with a propagation distance of 30 m from the centre of the measured lane. Microphones 1, 2 and 3 were positioned at 7.5, 10 and 15 m from the centre of the measured lane, respectively (see Figure 4.5). Experimental analysis took place for a duration of 90 minutes on a weekday between 07:30 and 09:00 on 7 June 2019. Metrological information, traffic count and average speed were recorded as previously described.

Table 4.11 describes the composition of traffic flow during the 1-hour period of direct measurement in accordance with respective CNOSSOS-EU vehicle categorisation, velocity and meteorological conditions.

Table 4.12 describes the CNOSSOS-EU model results in the context of medium to high traffic flow on a major road outside an agglomeration (i.e. more than 3 million passages per annum). The table presents the direct measurement results recorded using Type 1 SLMs at four locations on the western perimeter of a two-lane single carriageway. Data supplied by TII were utilised in the generation of the CNOSSOS-EU model. The ground absorption factor was set to 0.7 and height line data were applied in accordance with data provided by TII. The road surface typology was based on the currently available Dutch classification SMA-NL8 (i.e. R-n105-sma-nl8).

Results

- Direct measurements at microphones positioned 7.5, 10 and 15 m from the centre of the measured lane recorded emission values of 77.8, 74.7 and 67.6 dB(A), respectively.

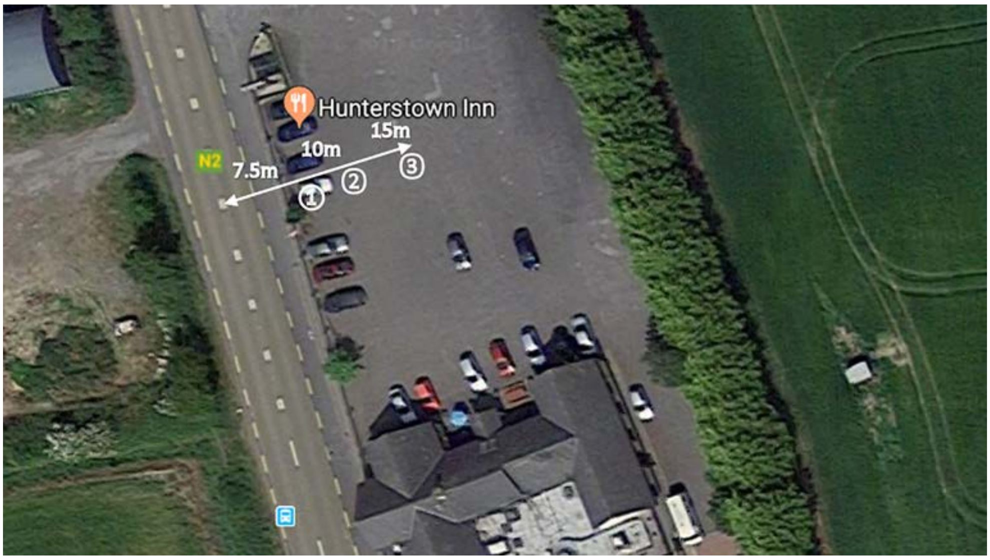

Figure 4.5. Experimental set-up for validation outside an agglomeration. Note: this Google image is used for illustrative purposes only and does not reflect *in situ* field conditions. No vehicles were present in the vicinity of equipment during the direct measurement period. Maps data: Google © 2019.

Table 4.11. N2 National Highway medium to heavy traffic composition and meteorological conditions

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 1	662	87	Temperature: 22.5°C, 295.65 K
Category 2	18	79	Pressure: 101.3 kPa
Category 3	64	81	Air humidity: 42.84%
Category 4a	0	0	Wind speed: < 2 m/s
			Wind direction: west
			Ground condition: dry
			Cloud cover: clear

Table 4.12. CNOSSOS-EU model validation – N2 National Highway analysis LA_{eq} dB(A)

Location	Distance from centreline (m)	SLM	CNOSSOS-EU model	Differential
1	7.5	77.8	73.0	–4.8
2	10	74.7	71.7	–3.0
3	15	67.6	69.9	2.3

- The CNOSSOS-EU model with receivers positioned 7.5, 10 and 15 m from the centre of the measure lane estimated emission values of 73, 71.7 and 69.9 dB(A), respectively, underestimating by –4.8 and –3 dB(A), and overestimating by 2.3 dB(A), respectively.

Conclusion

- Results correspond with the M1 experiment whereby the CNOSSOS-EU model estimates less accurately at roadside [i.e. 3–4.8 dB(A)] but more accurately in terms of propagation [i.e. 2.3 dB(A)].
- At a distance of 15 m from the centre of the measured lane, results from the CNOSSOS-EU model converge closely with direct measurements [i.e. 2.3 dB(A)].

Final conclusions

- Overall, results from all experiments indicate that the CNOSSOS-EU source model may converge more closely with direct measurements in the context of road sources within an agglomeration but are less accurate in the context of road sources outside an agglomeration. In the latter context, the CNOSSOS-EU propagation model converges more closely with direct measurement relative to the CNOSSOS-EU source model.[13] Future iterations of CNOSSOS-EU may improve the accuracy of the source model; however, it should be noted that, as the estimation of population exposure takes place at the dwelling façade, it is more important for the CNOSSOS-EU propagation model to function closer to direct measurements than the CNOSSOS-EU source model.
- Divergence in results between road sources measured within and outside agglomerations may be attributed to the following factors:
  - higher velocity of vehicles on road sources outside an agglomeration;
  - more category 2 and 3 vehicles outside an agglomeration.

4.3 Application of CNOSSOS-EU in the Context of Rail Sources

In order to evaluate the suitability of the CNOSSOS-EU method in the context of rail sources, an experimental analysis took place by way of a direct measurement campaign at locations representative of four rail source scenarios relevant to the Irish context and representative of the two major rail infrastructures operational in Ireland. These were:

- scenario 1: Irish Rail Network – DART, Commuter and InterCity fleet;

13 In this respect, it is important to note that the CNOSSOS-EU source model was originally developed from the Harmonoise/IMAGINE project, whereas the propagation model was developed from the NMPB-2008 model.

- scenario 2: Irish Rail Network – Commuter, InterCity and InterCity Enterprise fleet;
- scenario 3: Luas Tram Rail Network – straight track;
- scenario 4: Luas Tram Rail Network – curved track.

4.3.1 Methodology

In respect to case study location, the primary concern related to accessibility and the ability to position microphones in close proximity to respective rail sources. In this regard, several sites were investigated to ascertain suitability. After consideration, four site locations were selected: Shankill, Gormanstown, Cheeverstown and Fatima.

Although the currently available database with the noise prediction software contains only five example rail vehicle types under the CNOSSOS-EU method, all RMR vehicle classifications have been adapted and are present. For the purpose of this analysis these classifications were used to reference vehicles found in the Irish fleet. The respective vehicle type per section of track was selected from the currently available database, and parameters were modified accordingly.

Trackside microphones were positioned 7.5 m from the track centreline and at a source level height of 1.2 m, in accordance with ISO 1996-2:2017/BS 7445-1:2003 and ISO 3095:2013. In the context of propagation analysis, microphones were positioned at varying intervals[14] from the centreline of respective railheads at a source level height of 1.2 m. These microphones were positioned in order to assess the effect of the attenuation of noise due to propagation.

4.3.2 Results

Scenario 1: the Irish Rail network – DART, Commuter and InterCity fleet

The experiment was conducted on 1 May 2019 for the duration of 2 hours between 08:30 and 10:30 on a weekday. Direct measurement took place using Type 1 SLMs positioned at three locations on the western perimeter of the track location (see Figure 4.6 and Table 4.13). In the context of propagation analysis, microphones were placed at distances of 15 and 25 m from the track centreline in order to assess noise attenuation. Metrological information, vehicle count and average speed were recorded as previously described.

Table 4.13 describes the composition of rail vehicle passages during the 2-hour period of direct measurement according to fleet type, velocity and meteorological conditions.

Table 4.14 presents direct measurement results relative to estimated results generated by the CNOSSOS-EU model in the context of the Irish Rail network's DART, Commuter and InterCity fleet. Round 3 data supplied by Irish Rail were utilised in the generation of the CNOSSOS-EU model, and building height, building reflection factor (i.e. 0.8), ground absorption factor (i.e. $G = 0.7$) and height line data were applied according to this dataset. Track surface typology was based on the currently available "mono-block on hard rail pad" classification recommended by Irish Rail to reproduce parameters equivalent to a ballasted track typology. Owing to a lack of train information for the Irish fleet at the time of analysis, the following assumption was made: each train, comprising multiple vehicles, received the same category classification, with an amendment made to the rail vehicle catalogue database to account for vehicle length and number of axles. An average train length of 130 m was assumed, and a corresponding number of axles was selected. In the context of rail roughness, the currently available "average network" classification was applied, as visual inspection of the rail track and consultation with Irish Rail did not suggest that rail roughness was an issue at the case study location.

Results

- Direct measurements at microphones positioned 7.5, 15 and 25 m from the rail centreline measured emission values of 65.1, 61.8 and 59.1 dB(A), respectively.
- The CNOSSOS-EU model with receivers positioned 7.5, 15 and 25 m from the rail centreline estimated emission values of 63.2, 59.0 and 57.8 dB(A), respectively, underestimating by –1.9, –2.8 and –1.3 dB(A), respectively.

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14 Although there is no mention of specific propagation parameters for measuring rail noise in ISO, it was considered useful to include propagation microphones in order to assess the effect of the attenuation of noise due to propagation.

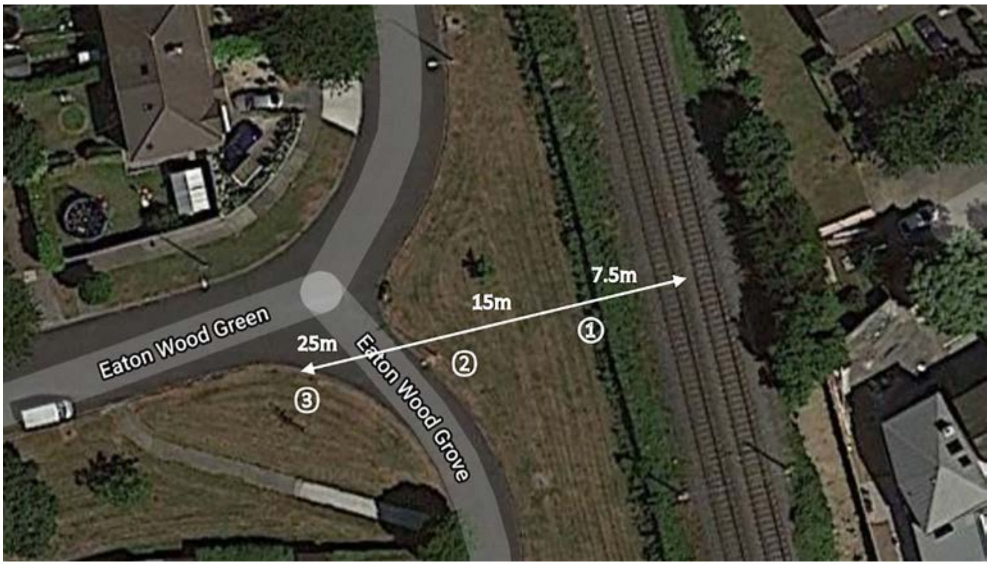

Figure 4.6. Irish Rail network – DART, Commuter and InterCity fleet experimental set-up. Maps data: Google © 2019.

Table 4.13. Shankill rail vehicle composition

Vehicle classification CNOSSOS-EU (Predictor)	Quantity	Velocity (km/h)	Meteorological conditions
Category 10 (DART EMU)	25	61	Temperature: 13.1°C, 286.25 K
Category 8 (Commuter DMU)	6	54	Pressure: 101.58 kPa
Category 19 (InterCity)	2	62	Air humidity: 83.89%
			Wind speed: < 2 m/s
			Wind direction: south
			Track condition: dry
			Cloud cover: partial to clear

EMU, electric multiple unit.

Table 4.14. CNOSSOS-EU model validation – Shankill rail sources analysis LA_{eq} dB(A)

Location	Distance from centreline (m)	SLM	CNOSSOS-EU model	Differential
1	7.5	65.1	63.2	–1.9
2	15	61.8	59.0	–2.8
3	25	59.1	57.8	–1.3

Conclusion

- In relation to Irish Rail vehicles (DART, Commuter and InterCity), predicted results generated from a CNOSSOS-EU model converge moderately with direct measurements [i.e. 1.3–2.8 dB(A)].

Scenario 2: the Irish Rail network – Commuter, InterCity and InterCity Enterprise fleet

The experiment was conducted on 1 May 2019 for the duration of 1 hour between 13:20 and 14:20 on a weekday. Direct measurement took place using Type 1 SLMs positioned at three locations on the western perimeter of the track location (see Figure 4.7 and Table 4.15). In the context of propagation analysis, microphones were placed at distances of 25 and 50 m from the track centreline to assess noise attenuation. Metrological information, vehicle count and average speed were recorded as previously described.

Table 4.15 describes the composition of rail vehicle passages during the 1-hour period of direct

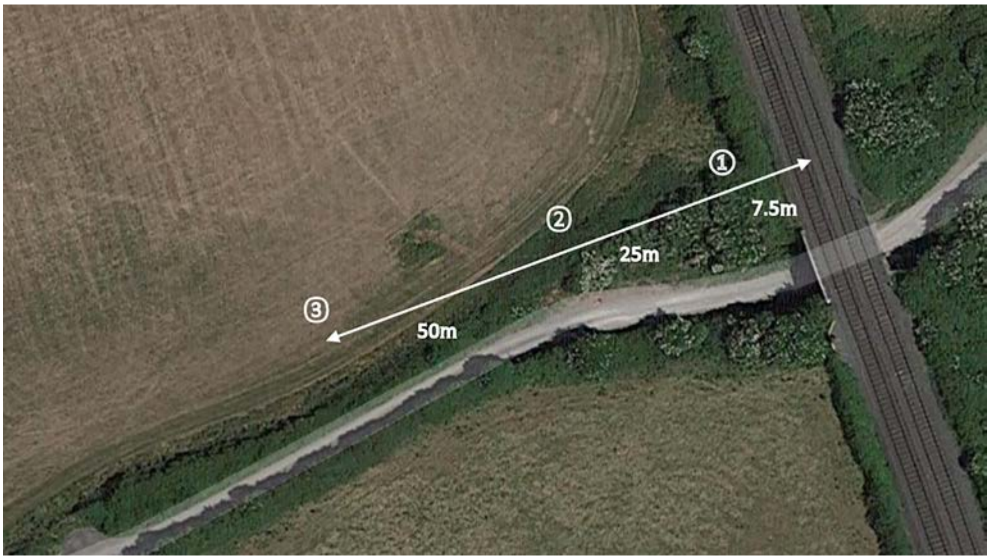

Figure 4.7. Irish Rail network – Commuter, InterCity and InterCity Enterprise fleet experimental set-up. Maps data: Google © 2019.

Table 4.15. Gormanstown rail vehicle composition

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 8 (Commuter DMU)	4	66	Temperature: 18.79°C, 291.95 K
Category 19 (InterCity)	1	70	Pressure: 101.53 kPa
Category 19 (InterCity Enterprise)	2	114	Air humidity: 44.4%
			Wind speed: 2.98 m/s
			Wind direction: south-west
			Track condition: dry
			Cloud cover: partial to clear

measurement according to fleet type, velocity and meteorological conditions.

Table 4.16 presents direct measurement results relative to estimated results generated by the CNOSSOS-EU model in the context of the Irish Rail network's Commuter, InterCity and InterCity Enterprise fleet. Round 3 data supplied by Irish Rail were utilised in the generation of the model, with parameters set as previously described. Track surface typology was applied as previously described, with considerations for bridge constant. An average train length of 130 m was assumed, and a corresponding number of axles was selected. Rail roughness parameters were applied as previously described.

Results

- Direct measurements at microphones positioned 7.5, 25 and 50 m from the rail centreline measured emission values of 65.8, 54.0 and 46.9 dB(A), respectively.
- The CNOSSOS-EU model with receivers positioned 7.5, 25 and 50 m from the rail centreline estimated emission values of 62.4, 54.2 and 50.2 dB(A), respectively, underestimating by

Table 4.16. CNOSSOS-EU model validation – Gormanstown rail sources analysis LA_{eq} dB(A)

Location	Distance from centreline (m)	SLM	CNOSSOS-EU model	Differential
1	7.5	65.8	62.4	–3.4
2	25	54.0	54.2	0.2
3	50	46.9	50.2	3.3

–3.4 dB(A) and overestimating by 0.2 and 3.3 dB(A), respectively.

Conclusion

- In relation to Irish Rail vehicles (Commuter, InterCity and InterCity Enterprise) in the Irish context, the predicted results generated from a CNOSSOS-EU model converge moderately with direct measurements [i.e. 0.2–3.4 dB(A)].
- The disparity of the model underestimating by –3.4 dB(A) at location 1 and overestimating by 3.3 dB(A) at location 3 may be accounted for by the combination of meteorological conditions. It is possible that the south-west wind direction coupled with the 2.98 m/s wind speed could have led to overestimation of the model at these locations.
- In addition, the application of a predominantly concrete/masonry bridge constant value may account for the model overestimation at location 3. The bridge constant penalty associated with the parameter may prove too severe in the context of propagation.

Scenario 3: Luas Tram Rail network – straight track

The experiment was conducted on 23 April 2019 for the duration of 100 minutes between 10:30 and 12:10 on a weekday. Direct measurement took place using Type 1 SLMs positioned at three locations on the northern perimeter of the track location (see Figure 4.8 and Table 4.17). Trackside measurements aimed to capture points of vehicle acceleration and deceleration entering and exiting stations. The Luas Tram Rail station in question is positioned 125 m east of location 3. In the context of propagation analysis, microphones were placed at a distance of 25 m from the track centreline. Metrological information, vehicle count and average speed were recorded as previously described.

Table 4.17 describes the composition of rail vehicle passages during the 100-minute period of direct measurement according to fleet type, velocity and meteorological conditions.

Table 4.18 presents direct measurement results relative to estimated results generated by the CNOSSOS-EU model in the context of the vehicles entering and exiting a nearby station and moving along a straight track. Round 3 data supplied by TII were utilised in the generation of the model, with parameters applied as previously described. Track surface typology was based on the currently available “mono-block on sleeper on soft rail pad” classification recommended by TII to reproduce parameters equivalent to a hard surface embedded track typology. For the purpose of modelling Luas Tram Rail vehicles, category 20 was selected from the CNOSSOS-EU database. This corresponds to RMR category 7. In addition to this selection, an amendment was made to the rail vehicle catalogue database to account for vehicle length and number of axles. An average tram length of 45 m was assumed and a corresponding number of axles was selected. Rail roughness parameters were applied as previously described.

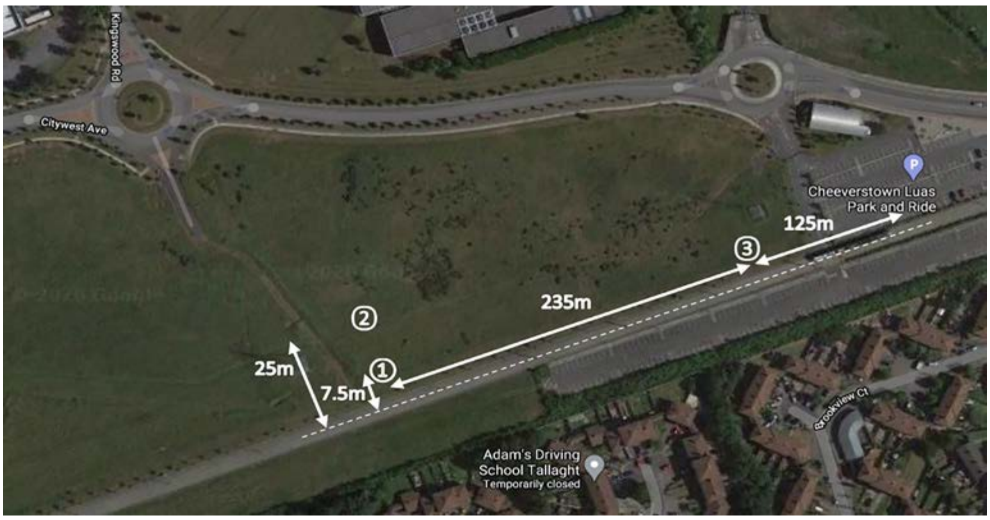

Figure 4.8. Luas Tram Rail network – straight track experimental set-up. Maps data: Google © 2019.

Table 4.17. Cheeverstown rail vehicle characteristics

Vehicle classification CNOSSOS-EU	Quantity	Velocity (km/h)	Meteorological conditions
Category 20 (Luas Tram Rail) – eastbound	10	60	Temperature: 14.85°C, 288 K
Category 20 (Luas Tram Rail) – westbound	10	59	Pressure: 98.25 kPa
			Air humidity: 75.2%
			Wind speed: < 2 m/s
			Wind direction: north-east
			Track condition: dry
			Cloud cover: partial to clear

Table 4.18. CNOSSOS-EU model validation – Cheeverstown Luas Tram Rail sources analysis LA_{eq} dB(A)

Location (metres from station)	Distance from centreline (m)	SLM	CNOSSOS-EU model	Differential
1 (360)	7.5	65.5	61.6	–3.9
2 (360)	25	52.1	54.4	2.3
3 (125)	7.5	61.6	61.9	0.3

Results

- Direct measurements at microphones positioned 7.5, 25 and 7.5 m from the rail centreline, and 360, 360 and 125 m from a nearby station, measured emission values of 65.5, 52.1 and 61.6 dB(A), respectively.
- The CNOSSOS-EU model with receivers positioned 7.5, 25 and 7.5 m from the rail centreline, and 360, 360 and 125 m from a nearby station, estimated emission values of 61.6, 54.4 and 61.9 dB(A), respectively, underestimating by –3.9 dB(A) and overestimating by 2.3 and 0.3 dB(A), respectively.

Conclusion

- In relation to Luas Tram Rail vehicles travelling along a straight track and in close proximity to a station, the predicted results generated from a CNOSSOS-EU model converge moderately with direct measurements [i.e. 0.3–3.9 dB(A)].
- As location 1 represents the point of vehicle acceleration/deceleration and location 3 represents vehicles travelling at a more constant speed, the results may suggest that the CNOSSOS-EU source model is less accurate at estimating points of acceleration/deceleration. Although the propagation model (i.e. location 2) appears to be generating more accurate results, it is worth considering in this regard that within the noise prediction software acceleration and deceleration parameters are not used in the CNOSSOS-EU model and, therefore, only constant speed and idle values are currently applied.

Scenario 4: Luas Tram Rail network – curved track

The experiment was conducted on 23 April 2019 for the duration of 50 minutes between 13:30 and 14:20 on a weekday. Direct measurement took place using Type 1 SLMs positioned at three locations on the northern perimeter of the track location and one location on the southern perimeter (see Figure 4.9 and Table 4.19). In this context, the trackside measurements aimed to capture points of vehicle acceleration and deceleration on entering and exiting a nearby station as well as the potential for the contribution of squeal noise due to track curvature. Metrological information, vehicle count and average speed were recorded as previously described.

Table 4.19 describes the composition of rail vehicle passages during the 50-minute period of direct measurement according to fleet type, velocity and meteorological conditions.

Table 4.20 presents direct measurement results relative to the estimated results generated by the CNOSSOS-EU model in the context of the vehicles entering and exiting a nearby station and moving along a straight track. Round 3 data supplied by TII were

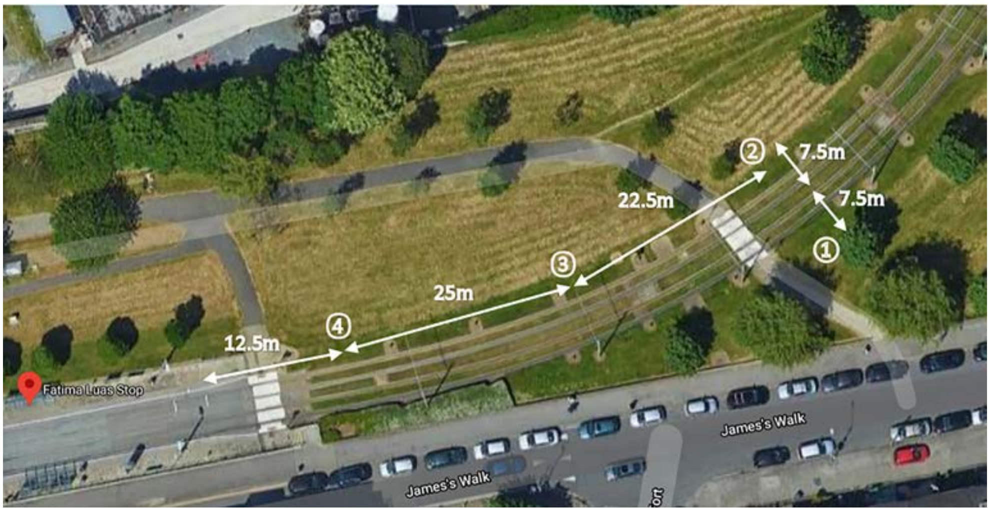

Figure 4.9. Luas Tram Rail network – curved track experimental set-up. Maps data: Google © 2019.

Table 4.19. Fatima rail vehicle characteristics

Vehicle classification CNOSSOS-EU (Predictor)	Quantity	Velocity (km/h)	Meteorological conditions
Category 20 (Luas light rail) – eastbound	10	27	Temperature: 14.85°C, 288 K
Category 20 (Luas light rail) – westbound	11	29	Pressure: 98.25 kPa
			Air humidity: 75.2%
			Wind speed: < 2 m/s
			Wind direction: north-east
			Track condition: dry
			Cloud cover: partial to clear

Table 4.20. CNOSSOS-EU model validation – Fatima Luas Tram Rail sources analysis LA_{eq} dB(A)

Location (metres from station)	Distance from centreline (m)	SLM [dB(A)]	CNOSSOS-EU model [dB(A)]	Differential [dB(A)]
1 (60)	7.5	59.7	62.1	2.4
2 (60)	7.5	60.3	63.0	2.7
3 (37.5)	7.5	59.4	62.7	3.3
4 (12.5)	7.5	60.0	62.3	2.3

utilised in the generation of the model, with parameters set as previously described. Track surface typology was based on the currently available “mono-block sleeper on soft rail pad” classification recommended by TII to reproduce parameters equivalent to a soft surface embedded track typology. For the purpose of modelling Luas Tram Rail vehicles, category 20 was selected from the currently available database. This corresponds to an RMR category 7. In addition to this selection, an amendment was made to the rail vehicle catalogue database to account for vehicle length and number of axles. An average tram length of 45 m was assumed and a corresponding number of axles was selected. Track curvature values were applied to a 50-m section of track, with appropriate values inputted to represent a 5 dB(A) increase in noise emission. Track curvature represented a radius of 120 m. A 50-m section of track was selected at the centre of the bend and assigned the radius of 400 m [representative of a 5 dB(A) penalty appropriate for light rail]. Rail roughness parameters were applied as previously described.

Results

- The trackside direct measurement recorded an average rail source emission value of 59.9 dB(A).
- The CNOSSOS-EU model estimated an average emission value of 62.5 dB(A), overestimating by an average of 2.6 dB(A).

Conclusion

- In relation to Luas Tram Rail in the Irish context, the predicted results generated from a CNOSSOS-EU model converge moderately with direct measurements near a station [i.e. 2.3–3.3 dB(A)].
- The results at points of acceleration/deceleration are dissimilar to the Cheeverstown straight track experiment. This may be attributed to significant differences in the velocity of the vehicle at these sites. Rail roughness may also have influenced results at this site.

Final conclusion

- In relation to both Irish Rail and Luas Tram Rail, in most cases direct measurements are outside the 2 dB(A) quality criterion compared with estimated results from CNOSSOS-EU modelling. These results further emphasise the requirement for the recommendation presented in the section "Rail vehicle type under CNOSSOS-EU" (in section 3.2.2), relating to the necessity for a modified rail vehicle XML catalogue to be generated in order to better represent the Irish fleet in its entirety.

5 An Assessment of Past Noise Mapping Results under CNOSSOS-EU[15]

5.1 An Assessment of Past Noise Mapping Results for Road Sources within Agglomerations

The first stage in the assessment of previous noise mapping results vis-à-vis expectations under CNOSSOS-EU for road sources involves using round 3 models where CRTN was used as the calculation model. It also involved the generation of new models using the CNOSSOS-EU method. For Dublin city, the CRTN model was generated using the CRTN-TRL (Transport Research Laboratory) calculation Method 2; for South Dublin, Fingal, Dún Laoghaire–Rathdown and Cork city, the CRTN-TRL calculation Method 3 was used. The second stage involved ascertaining the potential differences in population exposure calculated for respective local authority areas. Under the CRTN method, population exposure was based on assessment of noise levels at the most exposed façade of all residential buildings. Under the CNOSSOS-EU method, an assessment of noise levels at the most exposed façade for buildings with one dwelling is applied in combination with an assessment of noise levels at each respective façade for residential buildings with more than one dwelling. Calculation of inhabitants per building was estimated using CASE 1B criteria (EU, 2015; p. 93) in equation 5.1:

$$\mathrm{Inh}_{\mathrm{building}} = \frac{V_{\mathrm{building}}}{V_{\mathrm{total}}} \times \mathrm{Inh}_{\mathrm{total}} \tag{5.1}$$

5.1.1 Dublin City Council round 3 CRTN-TRL vis-à-vis CNOSSOS-EU

The composition of the DCC dataset applied in the round 3 strategic noise mapping process is described in Table 5.1.

Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to the CRTN-TRL method and the CNOSSOS-EU method are described in Table 5.2.

- L_{den} values < 55 dB(A) in the Dublin city local authority area accounted for 35% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 14%.
- L_{den} values > 55 dB(A) in the Dublin city local authority area accounted for 65% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 86%.

5.1.2 South Dublin round 3 CRTN-TRL vis-à-vis CNOSSOS-EU

The composition of the South Dublin dataset applied in the round 3 strategic noise mapping process is described in Table 5.3.

Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to the CRTN-TRL method and the CNOSSOS-EU method are described in Table 5.4.

- L_{den} values < 55 dB(A) at the most exposed façade of buildings in the South Dublin local authority area accounted for 83% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 51%.
- L_{den} values > 55 dB(A) at the most exposed façade of buildings in South Dublin local authority area accounted for 17% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 49%.

5.1.3 Fingal round 3 CRTN-TRL vis-à-vis CNOSSOS-EU

The composition of the Fingal dataset applied in the round 3 strategic noise mapping process is reported in Table 5.5.

Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to the CRTN-TRL method and the CNOSSOS-EU method are described in Table 5.6.

15 Results for all models were generated using Predictor-LimA, version 2019.3.

Table 5.1. Composition of the Dublin city round 3 dataset

Label	Description of road type	Range of traffic volume (18 h)	Length of road network (km)	%
Motorway	National primary (motorways)	964–65,688	52	3
N132–N1561	National secondary (N51–N1999)	5688–21,252	0.3	0
R101–R839	Regional (R100–R999)	140–97,208	220	11
L1001–L1500	Local primary (L1000–L4900)	300–43,16	9	5
L1505–L5163	Local secondary (L5000–L8999)	300–27,636	28	1
L10027–L17073	Local tertiary (L10001–L89999)	80–61,224	69	3
Blank field	Residential roads or minor urban roads	964	1460	72
		2244–65,688	104	5

Note: excluding buffer zone, median traffic volume (18 h) = 964; mean traffic volume (18 h) = 4220.

Table 5.2. Population exposure under CRTN-TRL and CNOSSOS-EU in the Dublin city LA area

	CRTN-TRL		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	193,262	35	75,164	14	–118,098	–21
55–59	198,138	36	227,504	41	29,367	5
60–64	36,724	7	141,807	26	105,084	19
65–69	72,067	13	62,764	11	–9303	–2
70–74	49,101	9	35,986	6	–13,115	–2
> 75	5264	1	11,329	2	6065	1

Table 5.3. Composition of the South Dublin round 3 dataset

Label	Description of road type	Range of traffic volume (18 h)	Length of road network (km)	%
Main roads	National primary (motorways)	1062–66,932	111	10
Second class	National secondary (N51–N99)	964–29,562	152	13
R109–R833	Regional (R100–R999)	1540–40,188	46	4
L1010–L3180	Local primary (L1000–L4900)	101–43,116	42	4
L5004–L5098	Local secondary (L5000–L8999)	1652–9120	2	0.2
L10149–L16938	Local tertiary (L10001–L89999)	80–31,152	18	2
First class	Link roads off motorways	964–17,349	27	2
Third class	Residential roads or minor urban roads	964	507	45
		2500–15,800	17	2
Blank label	Residential roads or minor urban roads	964	180	16
		100–50,983	29	3

Note: excluding buffer zone, median traffic volume (18 h) = 964; mean traffic volume (18 h) = 5983.

Table 5.4. Population exposure under CRTN-TRL and CNOSSOS-EU in the South Dublin LA area

	CRTN-TRL		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	232,559	83	141,977	51	–90,582	–32
55–59	20,885	7	71,492	26	50,607	18
60–64	21,134	8	32,716	12	11,582	4
65–69	3889	1	22,317	8	18,428	7
70–74	296	0	8197	3	7901	3
> 75	4	0	2068	1	2064	1

Table 5.5. Composition of the Fingal round 3 dataset

Label	Description of road type	Range of traffic volume (18 h)	Length of road network (km)	%
Main roads	National primary (motorways)	922–67,503	180	13
Second- class	National secondary (N51–N99)	964–16,877	23	2
R102–R843	Regional (R100–R999)	800–46,600	332	23
L1005–L3180	Local primary (L1000–L4900)	922–33,576	266	18
L5007–L6296	Local secondary (L5000–L8999)	800–27,636	7	0.5
L10042–L62806	Local tertiary (L10001–L89999)	800–62,982	24	2
Third- class	Residential roads or minor urban roads	964	59	4
		4864–11,590	3	0.2
Blank field	Residential roads or minor urban roads	964	352	24
		922–951	193	13

Note: excluding buffer zone, median traffic volume (18 h) = 3233; mean traffic volume (18 h) = 7521.

Table 5.6. Population exposure under CRTN-TRL and CNOSSOS-EU in the Fingal LA area

	CRTN-TRL		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	253,134	86	218,845	74	–34,289	–12
55–59	23,182	8	31,461	11	8279	3
60–64	16,402	6	22,736	8	6334	2
65–69	2813	1	19,751	7	16,938	6
70–74	484	0	3220	1	2736	1
> 75	5	0	7	0	2	0

- L_{den} values < 55 dB(A) at the most exposed façade of buildings in the Fingal local authority area accounted for 86% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 74%.
- L_{den} values > 55 dB(A) at the most exposed façade of buildings in the Fingal local authority area accounted for 14% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 26%.

5.1.4 *Dún Laoghaire–Rathdown round 3 CRTN-TRL vis-à-vis CNOSSOS-EU*

The composition of the Dún Laoghaire–Rathdown dataset applied in the round 3 strategic noise mapping process is described in Table 5.7.

Table 5.7. Composition of the Dún Laoghaire–Rathdown round 3 dataset

Label	Description of road type	Range of traffic volume (18 h)	Length of road network (km)	%
Motorway	National primary (motorways)	10,000–57,750	54	12
R114–R825	Regional (R100–R999)	680–40,188	35	8
L1009–L1440	Local primary (L1000–L4900)	2080–43,116	14	3
L5040–L5095	Local secondary (L5000–L8999)	5412–22,288	3	1
L10027–L16938	Local tertiary (L10001–L89999)	80–61,224	8	2
Blank label	Residential roads or minor urban roads	964	179	39
		250–58,702	169	37

Note: excluding buffer zone, median traffic volume (18 h) = 13,279; mean traffic volume (18 h) = 15,404. It is worth noting that the Dún Laoghaire–Rathdown dataset exhibited substantially higher median and mean traffic volumes than other local authority areas.

Table 5.8. Population exposure under CRTN-TRL and CNOSSOS-EU in the Dún Laoghaire–Rathdown LA area

	CRTN-TRL		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	124,950	57	60,063	28	–64,887	–30
55–59	39,652	18	61,349	28	21,697	10
60–64	34,926	16	55,391	25	20,465	9
65–69	15,837	7	34,709	16	18,872	9
70–74	2625	1	6392	3	3767	2
> 75	27	0	113	0	86	0

Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to the CRTN-TRL method and the CNOSSOS-EU method are described in Table 5.8.

- L_{den} values < 55 dB(A) at the most exposed façade of buildings in the Dún Laoghaire–Rathdown LA area accounted for 57% of the population under CRTN-TRL; for CNOOSOS-EU the corresponding figure was 28%.
- L_{den} values > 55 dB(A) at the most exposed façade of buildings in the Dún Laoghaire–Rathdown local authority area accounted for 43% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 72%.

5.1.5 Cork city round 3 CRTN-TRL vis-à-vis CNOSSOS-EU

The composition of the Cork city dataset applied in the round 3 strategic noise mapping process is described in Table 5.9.[16]

Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to the CRTN-TRL method and the CNOSSOS-EU method are described in Table 5.10.

- L_{den} values < 55 dB(A) at the most exposed façade of buildings in the Cork city local authority area accounted for 72% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 54%.
- L_{den} values > 55 dB(A) at the most exposed façade of buildings in Cork city local authority area accounted for 28% of the population under CRTN-TRL; for CNOSSOS-EU the corresponding figure was 46%.

5.2 Application of a More Extended Road Network to Round 3 Data

Analysis of round 3 data indicates that the extent of road source polyline data (excluding buffer zone) varies across local authorities. The following outlines round 3 data in relation to Ordnance Survey Ireland (OSi) PRIME2 data, which includes all official digital road sources:

- Dublin city round 3 road source data 1348 km – OSi PRIME2 data 1389 km (97%);
- South Dublin round 3 road source data 750 km – OSi PRIME2 data 1275 km (59%);
- Fingal round 3 road source data 719 km – OSi PRIME2 data 1842 km (39%);
- Dún Laoghaire–Rathdown round 3 road source data 206 km – OSi PRIME2 data 888 km (23%);
- Cork city round 3 road source data 156 km – OSi PRIME2 data 504 km (31%).

Please refer to section 7.1 for Noise-Adapt recommendations regarding this data requirement. The following exercise demonstrates the potential differential in population exposure when a more complete and representative road network is applied for noise modelling relative to that applied for round 3 (2017) strategic noise mapping. In doing so, it utilises a systematic application of default values derived from round 3 data applied using OSi road typology profiles. This exercise is intended to demonstrate the potential difference that incorporating a more comprehensive road network may have on estimates of population exposure to road traffic noise.

16 Cork city round 3 dataset contained only values for an 18-hour period and did not contain road polyline labels.

Table 5.9. Composition of the Cork city round 3 dataset

Range of traffic volume (18 h)	Length of road network (km)	%
420–1000	39	7
1000–5000	155	27
5000–10,000	171	30
10,000–20,000	151	27
20,000–30,000	31	5
30,000–59,876	17	3

Note: excluding buffer zone, median traffic volume (18 h) = 8990; mean traffic volume (18 h) = 4220.

5.2.1 South Dublin round 3 data – application of a more extended road network

A road typology profile derived from OSi PRIME2 data was applied to the South Dublin round 3 dataset to generate a systematic application of default values based on median road traffic volume for an 18-hour period (see Table 5.11).

These median values were extrapolated to the remaining road polylines contained in the OSi PRIME2 dataset in accordance with the OSi PRIME2 typology outlined in Table 5.13. Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to round 3 data and the application of a more extended road network is described in Table 5.12.

- L_{den} values < 55 dB(A) in the South Dublin local authority area accounted for 51% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 32%.
- L_{den} values > 55 dB(A) in the South Dublin local authority area accounted for 49% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 68%.

5.2.2 Fingal round 3 data – application of a more extended road network

A road typology profile derived from OSi PRIME2 data was applied to the Fingal round 3 dataset as previously described (see Table 5.13).

Default values were generated based on the round 3 median values cross-referenced with the OSi PRIME2 typology as previously described. Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to round 3 data and the application of a more extended road network are described in Table 5.14.

Table 5.10. Population exposure under CRTN-TRL and CNOSSOS-EU in the Cork city LA area

	CRTN-TRL		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	90,500	72	67,619	54	–22,881	–18
55–59	14,899	12	26,960	21	12,061	9
60–64	16,198	13	20,050	16	3852	3
65–69	3485	3	8280	7	4795	4
70–74	573	0	2695	2	2122	2
> 75	2	0	53	0	51	0

Table 5.11. Application of OSi road typology profile to the South Dublin round 3 dataset

OSi PRIME2 typology	Round 3 median traffic volume (18h)	OSi PRIME2 typology	Round 3 median traffic volume (18h)
Main road	28750	Fifth class	964
First class	12272	Sixth class (managed)	964
Second class	9788	Motorway on-ramp	11666
Third class	964	Motorway off-ramp	12298
Third class (access only)	964	National road on-ramp	14500
Fourth class	964	National road off-ramp	11000

Table 5.12. South Dublin round 3 data – application of a more extended road network

	Round 3 CNOSSOS-EU		Extended network CNOSSOS-EU	
L_{den} dB(A)	Number	%	Number	%
<55	141,977	51	88,969	32
55–59	71,492	26	89,810	32
60–64	32,716	12	66,618	24
65–69	22,317	8	22,543	8
70–74	8197	3	8346	3
>75	2068	1	2483	1

- L_{den} values <55 dB(A) in the Fingal LA area accounted for 74% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 42%.
- L_{den} values >55 dB(A) in the Fingal LA area accounted for 26% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 58%.

Table 5.13. Application of OSi road typology profile to Fingal round 3 dataset

OSi PRIME2 typology	Round 3 median traffic volume (18 h)
Main road	21,340
First class	8730
Second class	5725
Third class	925
Third class (access only)	964
Fourth class	964
Fifth class	964
Sixth class (managed)	964
Motorway on-ramp	9062
Motorway off-ramp	8301
National road on-ramp	4850
National road off-ramp	11,888

Table 5.14. Population exposure Fingal round 3 data – application of a more extended road network

	Round 3 CNOSSOS-EU		Extended network CNOSSOS-EU	
L_{den} dB(A)	Number	%	Number	%
<55	218,845	74	124,649	42
55–59	31,461	11	87,752	30
60–64	22,736	8	53,426	18
65–69	19,751	7	20,265	7
70–74	3220	1	7386	2
>75	7	0	2543	1

5.2.3 Dún Laoghaire–Rathdown round 3 data – application of a more extended road network

A road typology profile derived from OSi PRIME2 data was applied to the Dún Laoghaire–Rathdown round 3 dataset as previously described (see Table 5.15).

Default values were generated as previously described. Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to round 3 data and the application of a more extended road network are reported in Table 5.16.

- L_{den} values <55 dB(A) in the Dún Laoghaire–Rathdown LA area accounted for 28% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 19%.

Table 5.15. Application of OSi road typology profile to Dún Laoghaire–Rathdown round 3 dataset

OSi PRIME2 typology	Round 3 median traffic volume (18 h)
Main road	20,000
Second class	5733
Third class	964
Third class (access only)	964
Fourth class	964
Fifth class	964
Sixth class (managed)	964
Motorway on-ramp	20,000
Motorway off-ramp	25,650

Table 5.16. Population exposure Dún Laoghaire–Rathdown round 3 data – application of a more extended road network

	Round 3 CNOSSOS-EU		Extended network CNOSSOS-EU	
L_{den} dB(A)	Number	%	Number	%
< 55	60,063	28	41,138	19
55–59	61,349	28	78,987	36
60–64	55,391	25	54,803	25
65–69	34,709	16	34,784	16
70–74	6392	3	7763	4
> 75	113	0	543	0

- L_{den} values > 55 dB(A) in the Dún Laoghaire–Rathdown local authority area accounted for 73% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 81%.

5.2.4 *Cork city Round 3 data vis-à-vis OSi PRIME2 data (CNOSSOS-EU)*

A road typology profile derived from OSi PRIME2 data was applied to the Cork city round 3 dataset as previously described (Table 5.17).

Default values were generated as previously described. Excluding buffer zones, the results of population exposure estimation using L_{den} values in respect to round 3 data and the application of a more extended road network are reported in Table 5.18.

- L_{den} values < 55 dB(A) in the Cork city local authority area accounted for 54% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 35%.
- L_{den} values > 55 dB(A) in the Cork city local authority area accounted for 46% of the population when applied to round 3 data using CNOSSOS-EU; for the extended network, the corresponding figure was 65%.

Table 5.17. Application of OSi road typology profile to the Cork city round 3 dataset

OSi PRIME2 typology	Round 3 median traffic volume (18 h)
Main road	10,613
First class	10,670
Second class	9010
Third class	420
Third class (access only)	420
Fourth class	495
Fifth class	495
National road on-ramp	2744
National road off-ramp	455

Table 5.18. Population exposure Cork round 3 data – application of a more extended road network

	Round 3 CNOSSOS-EU		Extended network CNOSSOS-EU	
L_{den} dB(A)	Number	%	Number	%
< 55	67,619	54	43,980	35
55–59	26,960	21	31,089	25
60–64	20,050	16	33,064	26
65–69	8280	7	12,624	10
70–74	2695	2	4845	4
> 75	53	0	55	0

5.3 An Assessment of Past Noise Mapping Results for Rail Sources (Dublin Agglomeration)

Models for rail sources were generated using round 3 strategic noise mapping datasets for Luas Tram Rail and Irish Rail in the context of the Dublin agglomeration. All models were generated using the RMR-1996 and CNOSSOS-EU methods, respectively. In the context of Luas Tram Rail and RMR-1996 modelling, vehicles were classified under RMR category 7 (Urban Subway), whereas in the context of CNOSSOS-EU modelling, vehicles were classified under category 20 (Urban Subway) of the current Predictor-LimA database. In the context of Irish Rail and RMR-1996 modelling, vehicles were classified under RMR categories 3 (Mk4; Mark IV InterCity train), 4 (Freight), 6 (DMU/ICR) and 8 (EMU; electric multiple unit), whereas in the context of CNOSSOS-EU modelling, vehicles were classified under categories 14 (Mk4), 15 (Freight), 8 (DMU), 19 (ICR) and 10 (EMU) of the current Predictor-LimA database. In relation to the estimation of population exposure, under the RMR-1996 method, the estimation was based on assessment of noise level at the most exposed façade of all residential buildings. Under the CNOSSOS-EU method, an assessment of noise level at the most exposed façade for buildings with one dwelling is applied in combination with an assessment of noise levels at each respective façade for residential buildings with more than one dwelling. Calculation of inhabitants per building was estimated using CASE 1B criteria (EU, 2015, 93) in equation 5.1.

Tables 5.19–5.21 describe the results of population exposure estimation using L_{den} values in respect to the RMR-1996 method and the CNOSSOS-EU method in the context of Luas Tram Rail (Table 5.19), Irish Rail (Table 5.20) and all rail sources (Table 5.21).

- L_{den} values < 55 dB(A) in the Dublin agglomeration area accounted for 94% of the population under RMR-1996; for CNOSSOS-EU, the corresponding figure was 82%.
- L_{den} values > 55 dB(A) in the Dublin agglomeration area accounted for 6% of the population under RMR-1996; for CNOSSOS-EU, the corresponding figure was 18%.

Table 5.19. Luas Tram Rail population exposure under RMR-1996 and CNOSSOS-EU in the Dublin agglomeration

	Luas Green Line				Luas Red Line					
	RMR-1996		CNOSSOS-EU		RMR-1996		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%	Number	%	Number	%
< 55	94,889	94	96,627	96	140,181	95	141,348	96	2905	1
55–59	3125	3	2404	2	2796	2	2910	2	–607	0
60–64	2077	2	1241	1	3766	3	2545	2	–2057	0
65–69	338	0	241	0	451	0	396	0	–152	0
70–74	168	0	141	0	10	0	5	0	–32	0
> 75	74	0	17	0	0	0	0	0	–57	0

Table 5.20. Irish Rail population exposure under RMR-1996 and CNOSSOS-EU in the Dublin agglomeration

	RMR-1996		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	466,037	94.1	374,345	75.6	–91,692	–18.5
55–59	15,792	3.2	73,007	14.8	57,215	11.6
60–64	8911	1.8	33,041	6.7	24,130	4.9
65–69	3805	0.8	11,397	2.3	7592	1.5
70–74	442	0.1	3073	0.6	2631	0.5
> 75	28	0	152	0	124	0

Table 5.21. Total rail population exposure under RMR-1996 and CNOSSOS-EU in the Dublin agglomeration

	RMR-1996		CNOSSOS-EU		Differentials	
L_{den} dB(A)	Number	%	Number	%	Number	%
< 55	701,107	94	612,320	82	–88,787	–12
55–59	21,713	3	78,321	11	56,608	8
60–64	14,754	2	36,827	5	22,073	3
65–69	4594	1	12,034	2	7440	1
70–74	620	0	3219	0	2599	0
> 75	102	0	169	0	67	0

6 Assessment of Industrial Noise in Ireland

6.1 Industrial Noise and the Environmental Noise Directive

Since 2007 EU Member States have been legally obligated to generate SNMs and action plans every 5 years. The END states that a minimum requirement for SNMs is to place special emphasis on the noise emitted within agglomerations by road traffic, rail traffic, airports and industrial activity sites, including ports. Outside agglomerations, industrial noise mapping does not fall within the scope of the Environmental Noise Regulations or the END. Currently, Ireland does not map industrial noise under the terms of the END, indicating instead that the current Industrial Emissions Directive (IED) licensing arrangement provides appropriate protection. As stated in section 1 of the EPA Guidance Note for Noise (NG4),

> the strategic noise maps and noise action plans for the agglomerations need to include the assessment and control of noise from [IED]/IPPC [Integrated Pollution Prevention Control] licensed industrial sites if the noise emitted by such sites exceeds the thresholds which are to be reported to the public and EC, currently 55 dB L_{den} and 50 dB L_{night}. (EPA, 2016; p. 12).

An overview of results reported (EEA, 2017) to the European Commission regarding the strategic noise mapping of industrial noise in 2017 detail that, of the 36 European countries examined, three have no reporting obligation when it comes to noise exposure due to industrial sources. These countries are Ireland, Liechtenstein (no agglomeration > 100,000) and Luxembourg. Of the remaining 33 countries, all are required to produce strategic noise mapping of industrial noise.

6.2 Noise Assessment

In 2013, the IED licensing arrangement came into effect under Commission Directive 2010/75/EU (EU, 2010). An IED (formerly IPPC) licence is a single integrated licence that covers all emissions from a facility and its associated management. In the context of certain large-scale industrial facilities, control of noise emissions is exercised through IED licensing or through planning conditions. These licences are granted by the EPA and may have conditions attached to control noise, including emission limit values that must not be exceeded. The IED system has replaced both the IPPC and the Integrated Pollution Control (IPC) systems as the licensing regime applicable to relevant industrial activities in Ireland.

6.3 Noise Control and Mitigation

An EPA-licensed facility may be required to conduct noise assessments on an annual basis. The nature and scope of this assessment is determined by site-specific conditions and operational history. If it is the case that there has been a history of complaints regarding noise, the EPA may require a licensee to undertake a more extensive assessment. Noise measurement should be appropriate to the facility, and representative sampling intervals should be selected and justified. In relation to industrial noise, the EPA has drawn up a guidance document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)* (EPA, 2016). This provides general guidance and sets limits for licensed facilities. According to the document, licensed facilities should take all reasonably practicable measures to minimise the noise impact of the activity, and "Best Available Techniques" (BATs) should be used in the selection and implementation of appropriate noise mitigation measures and controls. Although BATs are applied on a case-by-case basis, the noise attributable to on-site activities should not generally exceed a free field $LA_{r,T}$[17] value of 55 dB(A) during the day (07:00–19:00) and a free field $LA_{r,T}$ value of 50 dB(A) during the evening (19:00–23:00) at any noise-sensitive location (NSL). At night (23:00–07:00), the noise attributable to

17 $LA_{r,T}$ is the equivalent continuous A-weighted sound pressure level during a specified time interval, T, plus specified adjustments for tonal character and impulsiveness of the sound.

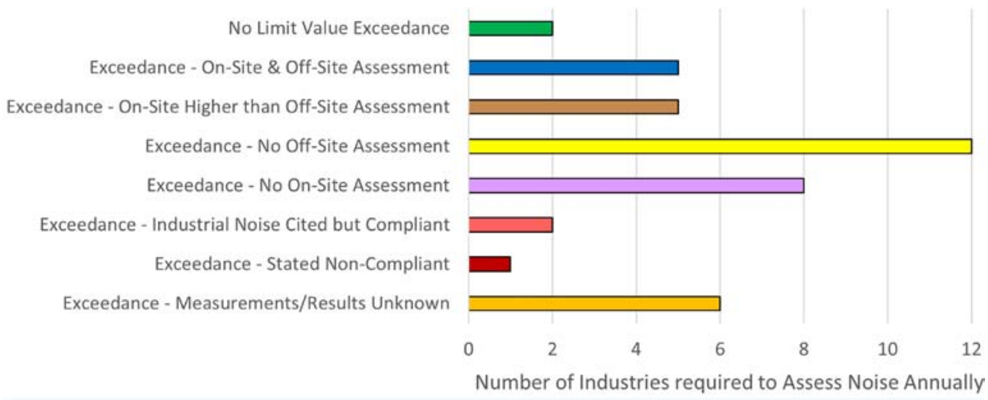

Figure 6.1. Annual industrial noise assessment results for the Dublin agglomeration (AER).

on-site activities should not exceed a free field $LA_{eq,T}$[18] value of 45 dB(A). While audible tones and impulsive noise should be avoided at all NSLs, especially at night, a penalty of 5 dB(A) for tonal and/or impulsive noise should be applied to the free field $LA_{r,T}$ day and evening-time measured values in order to convert them to $LA_{r,T}$. Annual noise assessments required under IED licensing arrangements are presented in the Annual Environmental Reports (AERs) of respective IED-licensed industries are required to submit to the EPA for the evaluation of the environmental performance in the previous reporting year. In the context of noise assessment, NG4 guidance states that "the fundamental requirements for the Annual Noise Survey are to determine whether or not the licensed activity complies with the noise limit values as set out in its licence and to ensure that there is no evidence of tonal or impulsive characteristics at night-time" (EPA, 2016; p. 39), whereby "the results of the Annual Noise Survey must be presented to the Agency … and should be reviewed and completed prior to the submission of the Annual Environmental Report (AER)" (EPA, 2016; pp. 41–42). AERs are submitted to the EPA for the evaluation of respective annual noise assessments in order to determine whether respective industries are compliant with EPA regulations or if it is necessary for Ireland to generate SNMs of industrial sources under the terms of Directive 2002/49/EC (EU, 2002).

6.4 Annual Environmental Report Review

In order to gain a better understanding regarding the annual assessment of noise from industrial sources in Ireland and how this process is regulated by the EPA, the Noise-Adapt team conducted a review of all AERs submitted between 2017 and 2019 for the Dublin and Cork agglomerations.[19] In the context of the Dublin agglomeration, 67 industrial sites were identified across 113 company locations. Of these 67 sites, 41 were required to assess noise on an annual basis. Results from noise assessment reports contained within submitted AER documents are quantified and illustrated in Figure 6.1.

Figure 6.1 illustrates that 2 of the 41 sites (5%) in the Dublin agglomeration reported no exceedance in limit values and stated compliance, whereas 30 of the 41 sites (73%) reported limit value exceedance but compliance, predominantly owing to the cited influence of external road traffic as the dominant source of noise (see also Appendix 3). Figure 6.1 also illustrates that the 30 sites that reported limit value exceedance but compliance present several different scenarios. As such, where limits are exceeded owing to cited external noise, only 5 of the 41 sites (12%) reported that both on-site and off-site measurements are performed. Furthermore, of these 5 sites, on-site measurements were lower than off-site measurements and thus results cannot be empirically attributed to external noise. Of the 41 sites, 12 (29%) do not

18 LA_{eq} is the A-weighted equivalent continuous sound level in decibels measured over a stated period of time.

19 AERs can be found under the Licence Enforcement Documents section of the EPA resource at http://www.epa.ie/terminalfour/ippc/index.jsp

conduct off-site measurements and thus results cannot be empirically attributed to external noise. Eight of the sites (20%) do not conduct on-site measurements and thus noise level results from industrial sources cannot be empirically identified (see Appendix 3). Of the remaining results, 2 of the 41 sites (5%) reported that industrial noise from the assessed premises is the reason for stating exceedance and compliance is stated. Of the 41 sites, 1 (2%) reported that the premises were non-compliant, whereas for 6 of the 41 (15%) sites, it was either not stated where measurements were taken or noise level statistics were not presented (see Appendix 3).

In the context of the Cork agglomeration, nine industrial sites were identified across 11 company locations. Of these nine sites, eight are required to assess noise on an annual basis. While one of these eight industrial sites in Cork agglomeration reported no exceedance in limit values and thus compliance, the remaining seven sites reported exceeding limit values (see Appendix 3). Of the eight sites, one site reported that both on-site and off-site measurements were performed but on-site measurements were higher than off-site measurements, another site did not conduct off-site measurements and two of the eight sites did not conduct on-site measurements (see Appendix 3). For three of the sites, it was not stated where measurements were taken or noise level statistics were not presented in the AERs (see Appendix 3).

The results indicate that there is an urgent requirement to reassess the suitability of the EPA's current IED licensing system. The most pertinent problem relates to the necessity for industrial sites to appropriately measure noise levels both on and off site if external noise is cited as the reason for exceeding noise limit values set by the EPA. A total of 12 sites in Dublin and one site in Cork that report noise limit exceedance state that external road traffic noise is the primary reason for such exceedance, although no off-site measurements are conducted as part of the industry's annual industrial noise assessment. If external noise is cited as the reason for exceeding limit values, external noise should be measured off site in order to empirically substantiate this claim. On the other hand, a total of eight sites in Dublin and two sites in Cork reported exceedance and cited external road traffic noise as the dominant source, but conducted no on-site measurements. If no on-site measurements are conducted, it is not possible to determine what is an industrial noise source and what is an external noise source. It was also seen that, although four sites in Dublin conducted both on-site and off-site measurements, as on-site results were reported as being higher than off-site results, it cannot be correctly concluded that external noise (i.e. off-site noise) is the dominant noise source causing exceedance without further investigation. Finally, it should also be noted that for six sites in Dublin and three sites in Cork it was either not stated where measurements were conducted – so any reference to external noise as the dominant source cannot be ascertained from reported results – or noise level statistics were not presented at all, resulting in the same conclusion.

6.5 Conclusion

The results of our review of annual noise assessments of industrial sources as presented in AERs submitted to the EPA indicate that it is currently not possible for the EPA to determine whether or not respective industries are, in fact, compliant with EPA regulations. In order to perform even a rudimentary classification of external noise as the reason for limit value exceedance, it is necessary to perform both on-site (internal) and off-site (external) measurements, so that a basic empirical delineation can be made between industrial noise emitted from the premises under assessment and other environmental noise emitting from an external source. Otherwise, such classification is not based on empirical evidence and conclusions in relation to compliance or otherwise cannot be drawn. In such cases, various assumptions are made in an effort to classify external noise sources that may be contributing to measured values.[20] It is owing to this classification that the responsible party charged with reporting these values is able to qualify that the measured values exceeding EPA limit values complies with IED licence terms. However, this classification is entirely based on subjective commentary and is unsupported by any empirical evidence. As previously stated, the results suggest that the suitability of

20 The most common assumption quoted relates to exceedance being the result of road traffic noise, whereas other assumptions cite bird song and alarms as factors in the classification of external noise sources. However, no evidence is provided to justify these assumptions.

the EPA's current IED licensing system needs to be reassessed, as it does not currently ensure that industrial sites are compliant with established noise limits at specific sites. The results clearly demonstrate a very high level of exceedance of established limits at industrial sites. Although this does not confirm non-compliance at these sites, it does outline the need for the sites in question to provide a more robust evidence base than is currently demonstrated for claiming compliance. This should be addressed in a future detailed review of the suitability of the current IED licensing system.

Please refer to section 7.2 for recommendations regarding how such issues may be addressed.

7 Recommendations

7.1 Recommendations for Future Noise Mapping Rounds under CNOSSOS-EU

7.1.1 Inclusion of additional road sources within agglomerations

In the context of strategic noise mapping of road sources there is a data requirement for responsible authorities to be aware of for future rounds of strategic noise mapping under CNOSSOS-EU. Although DCC has mapped the vast majority of road sources in round 3, other local authority areas, including South Dublin, Fingal, Dún Laoghaire–Rathdown and Cork city, have not. In certain cases, this may be due to difficulties obtaining traffic flow data. More generally, uncertainty regarding this issue may relate to the fact that Annex IV of the END (EC, 2002) does not specifically state that all roads within an agglomeration are required to be mapped. However, it is strongly implied. The END (2002/49/EC; EU, 2002) does not state that mapping major roads within agglomerations is sufficient for reporting. In fact, there is no indication anywhere in the legislation that only selected roads within agglomerations can/should be mapped. Such criteria are reserved for outside agglomerations where "major" roads over a certain passage threshold (3 million) are outlined. To estimate population exposure for agglomerations, and in line with the precautionary principle, the Noise-Adapt project recommends that all roads should be mapped in agglomerations where possible. The END also clearly states in section 1.6 of Annex VI that "it must also be indicated how major roads etc. contribute to the above" (EU, 2002). This explicitly indicates that roads other than major roads are expected to be mapped within agglomerations and that the contribution of major roads to exposure within agglomerations should be noted in reporting. The maps in Appendix 1 illustrate the contrast between road source polylines that have been mapped under the most recent round of (i.e. round 3) strategic noise mapping relative to road source polylines derived from the OSi officially designated road network based on the PRIME2 dataset.

> In summation, the Noise-Adapt project recommends that all noise mapping bodies work towards including a more extensive road network in future rounds of strategic noise mapping in line with the digitally available road system in the OSi PRIME2 dataset.

There are a number of recommendations as to how the traffic flow for additional road sources may be measured. The optimal solution would be to obtain traffic flow data using traffic flow modelling or traffic counts. However, this may not be feasible. An alternative solution would be to assign default values to roads where traffic counts are likely or known to have numbers below a certain annual figure (WG-AEN, 2007). The WG-AEN also recommends that traffic counts may be performed on a select sample of roads and then extrapolated to roads of the same type.

7.1.2 Estimation of population exposure in the Irish context

Commission Directive (EU) 2015/996 L 168/95 (EU, 2015; p. 95) regarding the estimation of population exposure is problematic. It reads "only for buildings with floor sizes that indicate a single dwelling per floor level, the most exposed façade noise level is directly used for the statistics and related to the number of inhabitants" (EU, 2015; p. 95). The text indicates that these buildings refer to residential buildings with more than one dwelling. No reference is made with regard to single dwelling units, which account for the vast majority of residential buildings in Ireland. However, a revision is expected whereby single dwelling units are specified under this parameter. Nevertheless, it must be noted that, as noise levels at single dwelling units are reported at the most exposed façade and noise levels at multiple dwelling units are reported for all facades, it is possible that estimates of populations exposed to noise > 55 dB(A) L_{den} and > 50 dB(A) L_{night} may be higher for nations with low-density urban profiles than for nations with high-density urban profiles. The Noise-Adapt project recommends that such issues be raised at the EU level so that estimates of population exposure are not overly influenced by an agglomeration's urban building/dwelling profile.

Furthermore, the calculation of inhabitants per building estimated using CASE 1B criteria (i.e. equation 5.1, as per Commission Directive (EU) 2015/996 L168/93), which is most applicable in the Irish context, does not currently account for buildings that serve as both residential and commercial dwellings.

> Therefore, the Noise-Adapt project recommends that this issue be raised at the EU level and that appropriate guidance is provided on how to calculate inhabitants for buildings that serve this dual residential/commercial function.

7.2 Assessing Industrial Noise in Ireland

A review of the assessment of industrial noise in Ireland has found that the vast majority of industrial sites required to assess noise levels on an annual basis exceed EPA limit values. As stated in section 6.1, and outlined by the EPA in NG4, SNMs and noise action plans "need to include the assessment and control of noise from [IED]/IPPC licensed industrial sites if the noise emitted by such sites exceeds the thresholds".

> In terms of providing evidence that an industrial site is not exceeding EPA noise limit values, the Noise-Adapt project recommends that the burden of proof should fall on the industrial site in question for demonstrating compliance with limits. Therefore, any effort to claim that the dominant noise source, for any instance of exceedance, does not originate from the site in question should be substantiated by empirical evidence.

It has been observed that, within NG4, it is deemed acceptable for noise emission attributes to be subjectively identified by a competent person familiar with noise impact assessment, for example "while, in most situations, a subjective assessment of the presence of tones and impulsive elements can be made, appropriate procedures for objective assessment are presented in Section 5.0 of this document" (EPA, 2016; p. 39) and "subjective comments on audibility and the dominance of noise sources should also be included along with difficulties in identifying sources etc." (EPA, 2016; p. 41).

> Although the methods for conducting a periodic noise assessment must remain cost-effective for the site in question, the Noise-Adapt project recommends that further attempts to remove such ambiguity from the noise assessment process should be made. The optimal solution would be to perform strategic noise mapping of all industrial sites in Irish agglomerations in line with the vast majority (26 of 28) [at the time these data were compiled] of other EU Member States.

If this is not feasible, noise data for the surrounding area derived from SNMs, which are already generated by relevant authorities in accordance with the END, could supplement current direct measurement being performed on site. A more robust method for filtering background noise and external noise sources while conducting noise assessment could be also be performed.

> Finally, if it is decided not to conduct strategic noise mapping of industries in line with other EU Member States, then the Noise-Adapt project recommends that a review of the current IED licensing system should be undertaken to include the provision of a new evidenced-based measurement (as opposed to subjective) approach for filtering background noise and external noise sources to ensure that noise being emitted from industrial sites can be accurately determined.

7.3 Towards a National Ambient Noise Strategy – Centralisation

Lack of co-ordination among responsible authorities is a commonly cited issue throughout the EU (Guarinoni *et al*., 2012). In the context of Ireland, for strategic noise mapping rounds 2 and 3, TII has worked successfully with both regional local authorities in the context of road sources outside agglomerations and with the Rail Procurement Agency (RPA) in the context of rail sources. However, in relation to road sources within agglomerations, a centralised approach has not been adopted in Ireland. In this respect, Noise-Adapt focus group research with Irish local authorities emphasised how a lack of co-ordination among Irish authorities is problematic, citing the need for a more co-ordinated approach to data collection, with better co-operation between responsible bodies also required so that all authorities implement strategic noise mapping and risk assessment in a uniform manner. If the END is to be successfully implemented across EU Member States then a comprehensive and systematic national strategy for the evaluation and supervision of environmental noise should be generated. In the UK, the implementation of the END through the strategic noise mapping process for major roads, railways and agglomerations is managed by a single body (the Department for Environment, Food and Rural Affairs – Defra), with the national airport authority responsible for airports (Turner and Grimwood, 2009). In the Netherlands, a national support unit has been established that is responsible for progress control and provides knowledge-building tools and information exchange facilities via a tailor-made website, and which facilitates networking and regular meetings between responsible authorities (de Vos, 2009). Focus group research with Irish local authorities identified the need for a more centralised approach for strategic noise mapping to ensure consistency and to avoid difficulties related to managing various departments involved in the process. Reflecting the situation in the Netherlands, focus group findings also emphasised the need for the development of shared resources to carry out actions for multiple local authorities, which would not only develop consistency and be more time-efficient, but would also be a more efficient use of resources.

> Hence, before a national ambient noise strategy can be realised, the Noise-Adapt project recommends that responsibility for the strategic noise mapping process be centralised in a single body in the Irish context.

7.4 Implications of CNOSSOS-EU for Key Areas of Irish Policy

The END implies that planning strategy at local, regional and national levels has the potential to be included in future noise abatement projects, e.g. "acoustical planning" shall mean controlling future noise by planned measures, such as long-use planning, systems engineering for traffic, traffic planning, abatement by sound insulation measures and noise control of sources" (Directive 2002/49/EC L 189/14; EU, 2002). In Ireland, the National Planning Framework (DHPLG, 2018) includes a specific policy objective for the proactive management of noise where it is deemed likely to have a significant adverse impact on health and quality of life, aiming to support Environmental Noise Regulations through national planning guidance and noise action plans. For this reason, under the Sustainable Energy Authority of Ireland (SEAI), and in line with Directive 2014/52/EU, government-funded plans and programmes are required to conduct acoustic assessments as part of the Environmental Impact Assessment Reports (EIARs) submitted to EPA Ireland. The introduction of the new standardised CNOSSOS-EU methodology provides an opportunity for acoustical planning to play an even greater role in key areas of Irish policy, including transport, health, the environment and planning. If acoustical planning is to be given a more prominent role in such policy arenas, and indeed a national planning strategy, then the issue of environmental noise must be taken seriously at a political level and, thus, must be funded accordingly. Lack of financial resource continues to be a primary obstacle to achieving the objectives of the END in the Irish context. Noise-Adapt research with local authorities revealed that "lack of human resources" and "lack of financial resources" were considered to be the main challenges to meeting END requirements. Ultimately, this indicates that the END has failed to advance the political profile of noise as a serious health risk to improve public health. The development of a national ambient noise strategy, as well as the development of policy at the local and regional levels, adhering to the broader national strategy, would enable the co-ordination of environmental noise abatement nationally and ensure consistency in noise abatement strategies in Ireland. The requirement for this recommendation is also seen through results from focus group research with Irish local authorities. In this context, findings suggest that local authorities are not adequately resourced to challenge acoustic impact assessments and proposed abatement strategies associated with proposed developments.

The Noise-Adapt project recommends that the issue of environmental noise be given greater political emphasis by the European Commission so that it is taken more seriously at the national political level and, thus, funded accordingly. Nationally, the Noise-Adapt project recommends that a national ambient noise strategy be developed in conjunction, and in line, with local and regional policy.

8 Conclusion

This document has presented a summary of the main research findings, including recommendations for future rounds of strategic noise mapping, associated with the EPA-funded Noise-Adapt project. This document is intended to support the transition to CNOSSOS-EU approaches under the END, informed by a high-quality data analysis coupled with policy and practice recommendations to integrate and embed environmental noise pollution issues within various policy domains.

In terms of the main objectives of the project, the provision of a data needs/gaps assessment for adapting to CNOSSOS-EU for road and rail, and an assessment of CNOSSOS-EU methodology limitations likely to impede successful implementation were presented in Chapters 2 and 3.[21] In the context of road sources, analysis focused on recommendations regarding vehicle classification, average speed and the identification of traffic light and roundabout intersections within agglomerations. For rail sources, analysis focused on track and structure transfer function, rail roughness, impact noise, track curvature and vehicle properties, with the recommendation that a modified rail vehicle XML catalogue is created to better represent the Irish fleet.

An evaluation of the CNOSSOS-EU method within an Irish city (Dublin) and along a major road outside an agglomeration, as well as in the context of rail sources (i.e. Irish Rail and Luas Tram Rail), was presented in Chapter 4. In the context of road sources within an agglomeration, it was found that the CNOSSOS-EU model converged closely with direct measurements [i.e. within 2 dB(A)]. In the context of road sources outside an agglomeration, it was found that, although the CNOSSOS-EU propagation model converged closely with direct measurements, the CNOSSOS-EU source model performed less accurately. In the context of rail sources, direct measurement were found to be outside the 2 dB(A) quality criterion compared with estimated results from CNOSSOS-EU modelling, emphasising the necessity of generating a modified rail vehicle XML catalogue to better represent the Irish fleet in its entirety.

A reassessment of past strategic noise mapping data and population exposure estimates using CNOSSOS-EU was presented in Chapter 5. The results indicate that estimations of population exposure to road and rail sources > 55 dB(A) within agglomerations may increase relative to previous methodologies. In the context of road sources, it was also found that, although the DCC local authority area mapped the vast majority of road sources, other local authority areas did not.

The applicability of the CNOSSOS-EU method for estimating population exposure and the suitability of existing noise policy/legislation in the light of transitioning to CNOSSOS-EU was discussed in Chapter 7. In regard to the former, the Noise-Adapt project considers the estimate of population exposure within agglomerations to be overly influenced by urban building/dwelling profile, and that guidance is required regarding the calculation of inhabitants for buildings that serve both a residential and commercial function. In regard to the latter, the Noise-Adapt project recommends that a national ambient noise strategy is developed in conjunction with local and regional policy and that, before this is realised, responsibility for the strategic noise mapping process be centralised in a single body. This would enable the co-ordination of environmental noise abatement nationally and ensure consistency in noise abatement strategies in Ireland. It is also recommended that the issue of environmental noise be taken seriously at the political level and funded accordingly.

Developing strong practice guidance for environmental issues has the potential to stop unsustainable practices and reshape them in a manner that is more robust for the environment and for the health and wellbeing of the wider population more generally. The current shift towards the CNOSSOS-EU approach provides Irish authorities with the opportunity for a

21 See *Data Needs Assessment and Recommendations for Transitioning to CNOSSOS-EU* (full report), available for download at http://www.noisemapping.ie/useful-outputs.html

"reset moment" with respect to how they implement the END, with potential for Ireland to be a policy leader in the area. It is the firm aim of this report to assist relevant authorities through the development of strong evidence-based advice regarding the implementation of CNOSSOS-EU from 2022.

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Abbreviations

AER	Annual Environmental Report
BAT	Best Available Technique
CNOSSOS-EU	Common Noise Assessment Methods in Europe
CRTN	Calculation of Road Traffic Noise
dB(A)	Decibel(A)
DCC	Dublin City Council
DMU	Diesel multiple unit
EMU	Electric multiple unit
END	Environmental Noise Directive
EPA	Environmental Protection Agency
EU	European Union
HV	Heavy vehicle
ICR	InterCity Railcar
IED	Industrial Emissions Directive
IPPC	Integrated Pollution Prevention Control
ISO	International Organization for Standardization
LCS	Low-cost sensor
max	Maximum
min	Minimum
Mk4	Mark IV InterCity train
NSL	Noise-sensitive location
OSi	Ordnance Survey Ireland
RMR	Dutch Railway Noise Modelling Method (*Reken- en Meetvoorschrift Railverkeerslawaai*)
SAPS	Small Area Population Statistics
SCATS	Sydney Coordinated Adaptive Traffic System
S.I.	Statutory Instrument
SLM	Sound level meter
sma (also SMA)	Stone mastic asphalt
SNM	Strategic noise map
TII	Transport Infrastructure Ireland
TRL	Transport Research Laboratory
WG-AEN	European Commission Working Group Assessment of Exposure to Noise
WP	Work package
XML	Extensible markup language
zoab	Permeable concrete (*zeer open asfaltbeton*)

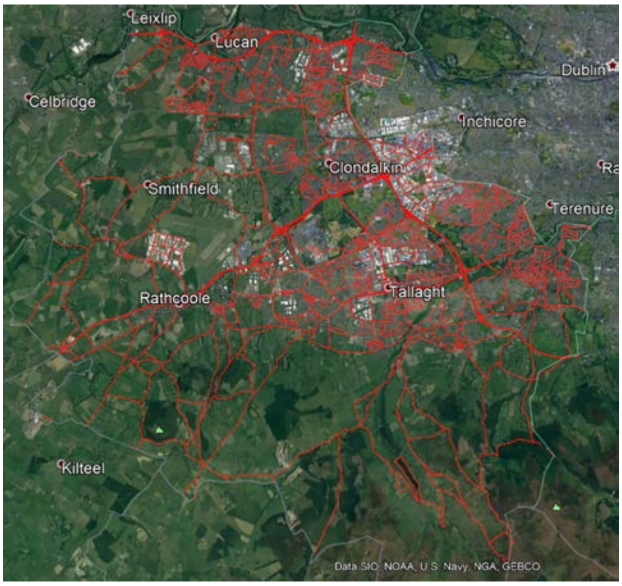
Glossary

Decibel(A)	An expression of the relative loudness of sounds in air as perceived by the human ear
LA_{eq}	A-weighted, equivalent continuous sound level in decibels measured over a stated period of time
$LA_{r,T}$	A-weighted, equivalent continuous sound pressure level during a specified time interval, *T*, plus specified adjustments for tonal character and impulsiveness of the sound
L_{day}	Day noise level; the A-weighted, L_{eq} (equivalent noise level) over the 12-hour day period (07:00–19:00). See Directive 2002/49/EC L 189/18
L_{den}	Day-evening-night noise level; the A-weighted L_{eq} (equivalent noise level) over a whole day, but with a penalty of 10 dB(A) for night-time noise (23:00–07:00) and of 5 dB(A) for evening noise (19:00–23:00). See Directive 2002/49/EC L 189/18
$L_{evening}$	Evening noise level; the A-weighted L_{eq} (equivalent noise level) over the 4-hour evening period (19:00–23:00). See Directive 2002/49/EC L 189/18
L_{night}	Night noise level; the A-weighted L_{eq} (equivalent noise level) over the 8-hour night period (23:00 to 07:00). See Directive 2002/49/EC L 189/18

Appendix 1 Round 3 Road Sources Data Relative to OSi PRIME2 Data

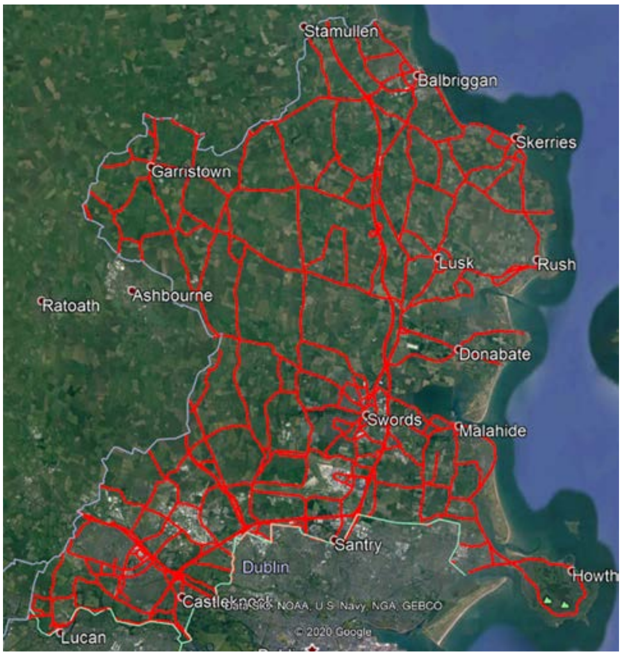
Maps showing (a) South Dublin round 3 modelling: application of road polylines 750 km; (b) South Dublin OSi PRIME2 dataset application of road polylines 1275 km; (c) Fingal round 3 modelling: application of road polylines 719 km; (d) Fingal OSi PRIME2 dataset application of road polylines 1842 km; (e) Dún Laoghaire–Rathdown round 3 modelling: application of road polylines 206 km; (f) Dún Laoghaire–Rathdown OSi PRIME2 dataset application of road polylines 888 km; (g) Cork city round 3 modelling: application of road polylines 156 km; and (h) Cork city round 3 modelling: application of road polylines 504 km.

(a)



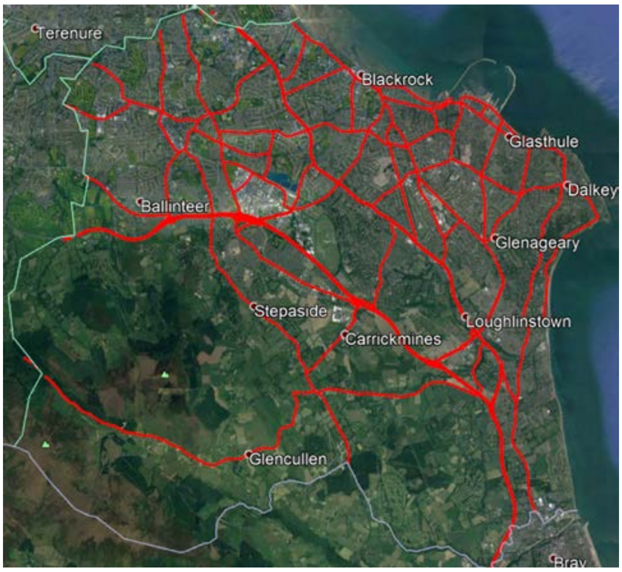
(b)

(c)



(d)

(e)



(f)

(g)

(h)

Maps data: Google © 2020.

Appendix 2 Sensitivity Analysis Results

Table A2.1. Sensitivity analysis – CRTN-TRL vis-à-vis CNOSSOS-EU (medium to heavy traffic flow) dB(A)

Microphone/ receiver[a]	SLM	CNOSSOS-EU model	CNOSSOS-EU differential	CRTN-TRL method 3	CNOSSOS-EU CRTN-TRL method 3 differential	CRTN-TRL method 2	CNOSSOS-EU CRTN-TRL method 2 differential
Roadside (7.5 m)							
East lane							
5	72.6	71.8	–0.8	70.7	–1.2	69.7	–2.2
6	72.8	71.9	–0.9	70.3	–1.7	69.3	–2.7
7	72.6	71.9	–0.7	70.6	–1.4	69.6	–2.4
8	72.6	72.3	–0.3	71.4	–1	70.4	–2

[a]Except where otherwise stated, all receivers are set at a ground-level height of 1.5 m.

Table A2.2. Sensitivity analysis – category 2 and 3 vehicles[a] (medium to heavy traffic flow) dB(A)

Receiver	Heavy vehicle analysis at 50 km/h				
Roadside (7.5 m)	**50/50**	**30/70**	**Differential**	**70/30**	**Differential**
1	72.1	72.4	0.3	71.9	–0.2
2	72.1	72.4	0.3	71.9	–0.2
3	72.2	72.4	0.2	71.9	–0.3
4	72.6	72.8	0.2	72.3	–0.3
Propagation (30 m)					
5 (30 m)	67.2	67.5	0.3	67	–0.2
6 (height = 4 m)	66.2	66.5	0.3	66	–0.2
Receiver	**Heavy vehicle analysis at 60 km/h**				
Roadside (7.5 m)	**50/50**	**30/70**	**Differential**	**70/30**	**Differential**
1	72.8	73.1	0.3	72.6	–0.2
2	72.8	73.1	0.3	72.6	–0.2
3	72.9	73.2	0.3	72.6	–0.3
4	73.3	73.6	0.3	73	–0.3
Propagation (30 m)					
5	67.9	68.2	0.3	67.7	–0.2
6 (height = 4 m)	66.9	67.2	0.3	67	0.1

[a]This analysis was performed in a scenario whereby 10% of total traffic flow was represented by HVs. According to Dublin city round 3 data, 88%, 11% and 0.7% of road polylines represent 0%, 1–10% and 11–22% of HVs, respectively.

Table A2.3. Sensitivity analysis – category 4 vehicles[a] (medium to heavy traffic flow) dB(A)

Receiver	Category 4 analysis					
Roadside (7.5 m)	Category 1 no MBIKE at 50 km/h	Category 4 at 50 km/h	Differential	Category 1 no MBIKE at 60 km/h	Category 4 at 60 km/h	Differential
1	70.4	70.6	0.2	71.5	71.5	0
2	70.6	70.6	0	71.5	71.5	0
3	70.6	70.6	0	71.5	71.5	0
4	71	71	0	71.9	71.9	0
Propagation (30 m)						
5	65.6	66	0.4	66.5	66.9	0.4
6 (height = 4 m)	64.7	65	0.3	65.6	65.8	0.2

[a]This analysis was performed in a scenario whereby 5% of total traffic flow was represented by category 4 vehicles. In Ireland, figures from the CSO (2017) describe a total of 63,474 (1.77% of total vehicle registration) new category 4 vehicles registered for the period.

Table A2.4. Sensitivity analysis – velocity (medium to heavy traffic flow) dB(A)

Receiver	Velocity				
Roadside (7.5 m)	44 km/h	50 km/h	Differential	60 km/h	Differential
1	71.9	72.3	0.4	72.7	0.8
2	72	72.4	0.4	72.8	0.8
3	72	72.4	0.4	72.8	0.8
4	72.4	72.8	0.4	73.2	0.8
Propagation (30 m)					
5	65.9	66.3	0.4	66.7	0.8
6 (height = 4 m)	65.7	66.2	0.5	66.3	0.6

Table A2.5. Sensitivity analysis – track type classification CNOSSOS-EU dB(A)

Track type	Receiver position[a] from centreline		
	1 (7.5 m)	2 (15 m)	3 (30 m)
Empty track transfer function	56	52.5	48.7
Min	56	52.5	48.7
Mono-block sleeper on soft rail pad	59.6	56.1	51.5
Mono-block sleeper on medium stiffness rail pad	58.7	55.2	50.9
Mono-block sleeper on hard rail pad	58.3	54.9	50.6
Bi-block sleeper on soft rail pad	59.5	56	51.4
Bi-block sleeper on medium stiffness rail pad	58.4	54.9	50.7
Bi-block sleeper on hard rail pad	57.8	54.3	50.2
Wooden sleepers	58.7	55.2	50.7

[a]In the context of rail sources, all receivers are set at a height of 1.2 m.

Table A2.6. Sensitivity analysis – structure transfer CNOSSOS-EU dB(A)

	Structure transfer analysis			
Receiver position	Empty superstructure transfer function	Min	CNOSSOS-EU default	Differential
1 (7.5 m)	59.6	59.6	59.6	0
2 (15 m)	56.1	56.1	56.1	0
3 (30 m)	51.5	51.5	51.5	0

Table A2.7. Sensitivity analysis – rail roughness CNOSSOS-EU dB(A)

	Rail roughness analysis				
Receiver position	Empty rail roughness	Min	EN ISO 3095:2013	Average network	Differential
1 (7.5 m)	63.8	55.6	57.8	59.6	8.2
2 (15 m)	60.2	52.1	54.3	56.1	4
3 (30 m)	56	47.8	49.9	51.5	3.7

Table A2.8. Sensitivity analysis – impact noise CNOSSOS-EU dB(A)

	Impact noise analysis			
Receiver position	Empty impact	Min	Single switch/joint/crossing/100 m	Differential
1 (7.5 m)	59.6	59.6	70.1	10.5
2 (15 m)	56.1	56.1	66.6	10.5
3 (30 m)	51.5	51.5	61.1	9.6

Appendix 3 Dublin and Cork IED/IPPC Licensed Facilities Result Summaries

Table A3.1. Dublin and Cork IED/IPPC licensed facilities result summaries

Facility	Are EPA limits being exceeded? Reason for exceedance	Is external noise measured? [dB(A)]
Dublin sites		
Advanced Environmental Solutions Ltd	Yes. External traffic cited. Only day measured	Yes. OSM = 63–72 day; NSL = 67–73 day
Amgen Technology	No. Traffic on and off premise cited	No
Astellas Ltd	Yes. No period referenced	Yes, but NSL lower than OSM. OSM = 58–59; NSL = 31–37
Becton Dickinson Insulin Syringe Ltd	Yes. Traffic on and off site, trees, birds, construction, aircraft – cited but no external measures	No. OSM = 48–58 day; 52–57 evening; 44–57 night
BOC Gases Ltd	Yes. External traffic, motors (on-site). External noise not measured. Internal noise (i.e. motors) exceeding limits not addressed	No. OSM = 56–85 day
Clarochem Ltd	No. No comments	
Diageo Ireland, St. James's Gate	Yes. "Noise measurements on Watling Street and Bonham Street were influenced by audible noise levels from the operating plant"	Yes. "As with previous noise monitoring results, Diageo incorporates the findings into its noise management programme and this will continue, taking into account the completion of all development works at the site"
Dublin City Council	Yes. Not indicated where noise levels are measured. Comments refer to road traffic noise as dominant source	Unknown. OSM/NSL = 55–68 day; 48–51 night
Dublin Waste to Energy	Yes. No reason provided for exceedance	No. OSM = 57–62 day; 46–59 night
Enva Ireland Ltd	Yes. External traffic, industrial noise from other sites. Evening not measured	Yes. OSM = 52–66 day. NSL = 63–64 day; 52 night
Fingal County Council	Yes. "Tail-lights banged against the truck as it passed over the speed bump". No industrial noise cited but no internal noise measured	Yes, but no OSM. NSL = 46–62 day. No noise generated at night
Forest Laboratories Ireland Ltd	No day. Yes night. Traffic, aircraft, trucks in industrial estate. No industrial noise cited but no internal noise measured	Yes, but no OSM. NSL = 42–48 night
Galco Steel Ltd	Yes. Not indicated where noise levels are measured. No comments	Unknown. 55–65 day; 55–58 evening
Greyhound Recycling and Recovery	Yes. No period referenced. External traffic cited but source not measured	No. 48–69
Guerbet Ireland	Yes. Traffic but source not measured	No. 46–70 day; 52–59 evening; 42–53 night
Henkel Ltd	Yes. Plant noise cited for exceedance at NSL at night, though still stated as compliant	Yes. OSM = 54–64 day; 53–60 evening; 52–54 night. NSL = 64 day; 63 evening; 49 night
Huntstown Power Company Ltd	Yes. Traffic noise cited, plant not audible	Yes, but no OSM. NSL = 72–75 day; 60–64 evening, 52–63 night
Indaver Ireland Ltd W0036–02	Yes. Traffic and other industrial sites cited but no external measures. Evening and night not measured	No. OSM = 88–68 day
Ipsen Ltd	No results reported. Compliance stated	Unknown

Table A3.1. Continued

Facility	Are EPA limits being exceeded? Reason for exceedance	Is external noise measured? [dB(A)]
Irish Packaging Recycling	Yes. Not indicated where noise levels are measured. Comments refer to road traffic noise as dominant source. Evening not measured	Unknown OSM/NSL = 55–61 day; 52–55 night
Irish Tar & Bitumen Suppliers	No results reported. Compliance stated	No
Lagan Bitumen Ltd	Yes. Night exceeded. External traffic cited but no measurement	No. OSM = 52–54 day; 45–47 night
Lawlor Brothers Ltd, trading as Access	Yes. Traffic cited as dominant source. No industrial noise cited, but no internal noise measured	Yes, but no OSM. NSL = 69 day; 55–60 night
Metal Processors Ltd	Only AER to state non-compliance, but comments “Due to the proximity of nearby sites in addition to the fact that the sound was not recorded during all three monitoring periods it cannot be directly attributed to noise generated on site”. Evening and night periods not measured	Yes. OSM = 53–68 day, NSL = 70 day. No corrective action presented. Results (i.e. NSL greater than OSM) are similar to sites that measure both internal and external noise and state compliance
Mondelez Ltd	Yes. External traffic cited but not measured	No. OSM = 55–71 day; 53–67 night
Pacon Waste & Recycling	Yes. No reason provided for exceedance during evening and night periods	No. OSM = 42–51 day; 49–52 evening; 38–45 night
Padraig Thornton Waste Disposal Ltd	Yes. External traffic and other industries cited. No industrial noise cited but no internal noise measured. Evening period not measured	Yes, but no OSM. NSL = 55–71 day; 56–67 night.
Pfizer Ireland Pharmaceuticals	Yes. External traffic cited	Yes, but no OSM. NSL = 59–68 day; 41–64 evening; 38–55 night
Rilta Environmental Ltd	Yes. “Installation operations not audible”, “Emissions arose from intermittent use of an angle grinder and forklift truck in the main onsite building, with sporadic hammering”	No. OSM = 52–64. Non-installation noise sources are not considered industrial noise – this is incorrect. Noted that site does not operate during evening and night
Rottapharm Ltd	Yes. External traffic cited. No industrial noise cited but no internal noise measured	Yes, but no OSM. NSL = 58–63 day; 60–63 evening; 52–54 night
SK biotek Ireland Ltd	Yes. External traffic, aircraft, construction cited	Yes. OSM = 63 day; 49 night. NSL = 54–73 day
South Dublin County Council	Yes. External traffic, trucks from nearby site cited. However, external measure lower than on-site measure therefore cannot state external factors. No external noise measured at night	Yes, but lower than on-site. OSM = 53–61 day; 44–50 night. NSL = 60 day
Starrus Eco Holdings Ltd	Yes. Not operational at night	Yes, but lower than on-site. OSM = 54–66 day, NSL = 54 day
Starrus Eco Holdings Ltd (D11)	Yes. Industrial sources cited. External measure lower than on-site measure. No evening measures	Yes, but lower than on-site. States that on-site measure do not need to comply with limits. OSM = 57–70 day; 46–52 night. NSL = 69 day; 58 night
Starrus Eco Holdings Ltd (D24)	No results reported. Compliance stated	Yes, both OSM and NSL stated
Sun Chemical Inks	No results reported. Compliance unknown	Unknown
Swords Laboratories	Yes. External traffic and aircraft cited, site not audible. No evening measures, no night measures for NSL	Yes. OSM = 54 day; 48 night. NSL = 53–71 day
Synergen Power Ltd	Yes. External traffic cited. At night activity from Dublin port cited	Yes. OSM = 44 night. NSL = 60–71 day; 59–71 evening; 55–66 night
Takeda Ltd	Yes. External traffic cited but not measured. Evening not measured	No. OSM = 45–49 day; 44–48 night

Table A3.1. Continued

Facility	Are EPA limits being exceeded? Reason for exceedance	Is external noise measured? [dB(A)]
Hammond Lane Metal Company	Yes. External traffic, other industries cited. However, external measure lower than on-site measure therefore cannot state external factors. Stated that it is impossible to monitor noise exclusively from site operations. Site does not operate evening and night	Yes, but lower than on-site. OSM = 60–74 day, NSL = 63–68 day
Viridian Power Ltd	Yes. External traffic cited. No industrial noise cited but no internal noise measured	Yes, but no OSM. NSL = 72–75 day; 60–68 evening, 52–64 night
Cork sites		
BASF Ireland Ltd	No results reported. Compliance stated	Yes, both OSM and NSL stated
Cara Partners	Yes. Cara site and neighbouring facility stated for OSM. Traffic cited for NSL. No evening measures	Yes. OSM higher than NSL at night. OSM = 52–60 day; 50–57 night. NSL = 47–52 night
GALCO Ltd	Yes. No indication where noise levels are measured. No comments	Unknown. 68–70 day. 58–62 evening
Heineken Ltd	Yes. External traffic and industrial noise cited. No evening measures	Yes, but no OSM. NSL = 54–64 day; 44–60 night
Janssen Pharmaceutical Sciences	Yes. Only moderate traffic cited for day. Only occasional traffic cited for night	Yes, but no OSM. NSL = 63–69 day; 53–56 night. No evening measures
Smithkline Beecham Ltd	No. Low-level industrial noise and construction from neighbouring industry cited	Yes, but no OSM. NSL = 42–47 day; 41–43 night
Upjohn Manufacturing	No results reported. Compliance stated	Yes, both OSM and NSL stated
Wexport Ltd	Yes. Neighbouring industry cited but not measured	No. OSM = 55–56

OSM, on-site measurements; NSL, (measurement at) noise-sensitive location.

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d’earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d’Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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Transitioning to Strategic Noise Mapping under CNOSSOS-EU (Noise-Adapt)

Authors: Enda Murphy, Jon-Paul Faulkner, Henry J. Rice and John Kennedy

Identifying Pressures

In the European Union (EU), 113 million people are estimated to be exposed to noise pollution from transport sources and this is detrimental to their health and quality of life. Internationally, there is a growing evidence base that links noise from transport sources to health issues, including sleep disturbance, annoyance, heart disease, cognitive impairment, quality of life and mental health and wellbeing. This report addresses noise pollution from transport as a significant environmental pressure and public health concern by providing guidance that assists with the practical implementation of revisions to the Environmental Noise Directive (END; 2002/49/EC). Given that Ireland has a statutory obligation to meet the requirements of the END, this is a strategic national environmental priority. This document outlines research conducted to assist with the objective of implementing regulations set out in the END and, in doing so, assists with developing future national capacity that contributes towards meeting Ireland's legislative obligations under EU law.

Informing Policy

Internationally, this report contributes to improving the implementation of the END which utilises the CNOSSOS-EU (Common Noise Assessment Methods in Europe) methodology from 2019 onwards. Outputs from this report have the potential to inform EU and national guidance on the implementation of the END under CNOSSOS-EU. Nationally, the report contributes to policy by providing practical guidance for transitioning to the new CNOSSOS-EU noise modelling and mapping methodology, which may assist with the development of future Environmental Protection Agency guidance in this area. Furthermore, it has the potential to contribute to a range of national policy areas, creating a positive feedback loop between policies for transport, land use/spatial planning and environmental health. The report also aligns with identified national research priorities, namely improving the health of the population and building a safe and sustainable environment.

Developing Solutions

The development of strong guidance for implementing environmental legislation has the potential to assist with transitioning to more sustainable environmental practices, which can benefit the health and wellbeing of the wider population. The current shift towards the CNOSSOS-EU methodology for strategic noise mapping provides Irish and EU authorities with the opportunity for a "reset moment" with respect to implementation of the END. This report aims to assist authorities in developing strong evidence-based advice on how to implement CNOSSOS-EU. The report provides wide-ranging adaptation guidance for relevant stakeholders. In doing so, the report (1) provides a data needs/gaps assessment for adapting to CNOSSOS-EU for road and rail sources in Ireland; (2) evaluates the CNOSSOS-EU methodology to assess its suitability and shortcomings; (3) identifies an approach for implementing the CNOSSOS-EU methodology for estimating population exposure; (4) reassesses past Irish strategic noise mapping data and population exposure estimates using the CNOSSOS-EU methodology; (5) evaluates the current approach for assessment of industrial noise; and (6) provides key recommendations for future noise mapping rounds under CNOSSOS-EU.

EPA Research: McCumiskey House, Richiew, Clonskeagh, Dublin 14.

Phone: 01 268 0100
Twitter: @EPAResearchNews
Email: research@epa.ie

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