

Underestimation analysis of noise exposure

Methodological report



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Summary

This report summarizes the methodological steps that have been followed to calculate how many people exposed to the different noise sources is underestimated considering the END thresholds established for the noise sources to be analysed (agglomerations above 100.000 inhabitants, major roads above 3 million vehicles / year, major railways with more than 30.000 train passages per year and major airports with more than 50.000 movements per year) and for the threshold levels established in the END for Lden and Lnight, compared to the noise levels at which the WHO defined that negative health effects and impacts start to occur.

An analysis of the streets and railways' infrastructure covered by noise contour maps inside urban agglomerations have also been undertaken, to estimate the missing exposed people if all streets/railways would have been included in the strategic noise maps.

1 Objective

The objective of the current report is to describe the methodology that have been used to estimate the number of people exposed to noise that is not currently covered by the END, both in the areas actually covered by the END and also taking into account areas where the END is not applicable.

As outputs of the task, an excel file is being produced with the main data calculated at source level for agglomerations and major airports, and at country level for major roads and major railways, both for Lden and Lnight indicators. Moreover, maps outlining the percentage of data reported related to the total values estimated at country level have been produced for road and rail traffic exposure, both for Lden and Lnight indicators.

2 Introduction

The number of people exposed to harmful levels of noise based on the data submitted under the END is likely to be underestimated, given that the END does not comprehensively cover all urban areas, roads, railways and airports across Europe.

In this task, it is evaluated to which extent the END underestimates the number of people exposed to harmful levels of noise at EU level through a statistical approach combined with a GIS analysis to evaluate the number of people affected by noise in areas not covered by the END.

The proposed methodology includes the areas below the END noise reporting thresholds i.e. 55 dB Lden and 50 dB Lnight, as well as roads outside urban areas below 3 million passes a year, railways outside urban areas below 30,000 passes a year, and airports outside urban areas below 50,000 movements a year. An estimation of how many of those people are living in areas between 50,000 and 100,000 inhabitants is also provided.

The focus is on transport noise, so industrial noise inside agglomerations is not going to be estimated. Currently WHO guidelines does not determine potential threshold values for exposure to industrial noise, but the approach followed for the airports case could be applied in the future to industrial noise.

3 Methodology to estimate exposure values below the END thresholds for the END sources

The estimations summarized in the next sections are focused on the areas covered by the END (urban agglomerations above 100.000 inhabitants, major roads outside urban areas above 3 million passes a year, major railways outside urban areas above 30,000 passes a year, and major airports outside urban areas above 50,000 movements a year) but going below the noise thresholds specified for Lden and for Lnight in the END.

Negative health effects start to occur below the obligatory END thresholds of Lden 55 dB and Lnight. The WHO recommends (WHO Europe, 2018) reducing noise levels to 53 dB Lden and 45 dB Lnight for road traffic, 54 dB Lden and 44 dB Lnight for rail traffic, and 45 dB Lden and 40 dB Lnight for air traffic. Recent research suggests health effects even below these WHO guidelines (Engelmann et al, 2023).

The noise levels taken into consideration for calculating the exposure values below the END thresholds for the END noise sources and summarized in the resulting table of this task then, differ depending on the noise source that is being addressed, as indicated above.

In the case of road noise exposure and rail noise exposure inside urban areas, an extra analysis of the streets and railways' infrastructure covered by noise contour maps inside urban agglomerations have also been undertaken. This analysis will be used to estimate the potential missing people calculated as exposed to noise if all streets and all railways infrastructure would have been included in the strategic noise maps calculation.

3.1 Exposure estimation inside agglomerations

3.1.1 Agglomeration road exposure estimation

The input data used for the analysis is the reported and gap filled exposure data as reported for the DF4_8 strategic noise maps, described in Blanes et al, 2023.

Based on the methodology described in Engelmann et al, 2023, noise exposure below the END threshold levels per each noise source have been estimated, and the population exposed to the different noise bands have been transferred from 5 dB to 1 dB band exposure distribution.

By using these results, and using the WHO thresholds (WHO Europe, 2018) for road traffic noise, the number of people equal or above 53 dB Lden and 45 dB Lnight are estimated at city level.

For this source inside agglomerations, an extra analysis has been performed.

Based on the OpenStreetMap project (<https://www.openstreetmap.org/>), reference data for roads at country level can be downloaded from the portal geofabrik (<https://download.geofabrik.de/>).

Once downloaded, a selection of the road classes to be included in the analysis has been undertaken based on the attribute "fclass": all roads segments not classified as 'service', 'cycleway', 'footway', 'living_street', 'pedestrian', 'path', 'steps' has been included in the analysis.

The resulting road infrastructure have been overlaid with the noise contour maps provided at agglomeration level for road traffic noise following the END specifications, to calculate percentage of the streets covered by the noise contour maps.

If the percentage is below 100%, then it is assumed that not all streets have been included in the calculation of the number of people exposed to road traffic noise, which could be a potential source of underestimation.

By using the percentage of streets covered per each agglomeration and the reported number of people exposed, the potential number of people exposed to road traffic noise at agglomeration level is calculated using the following formula:

$$\text{People estimated} = (\text{People reported} * 100) / \text{Streets percentage}$$

Where:

People estimated corresponds to the exposed number of people estimated to road traffic noise

People reported corresponds to the exposed number of people reported / gap filled to road traffic noise under the END requirements

Streets percentage corresponds to the percentage of streets covered by noise contour maps inside the END agglomeration

The calculation has been undertaken considering both, the END threshold values as well as the WHO threshold values and for Lden and Lnight indicators.

However, the noise contour maps inside urban areas are only provided on voluntary basis by member countries. In the cases where this information is not available, a mean percentage have been calculated at country level if some END agglomerations reported noise contour maps, or a mean percentage at European level if any contour maps have been reported for any agglomeration in a specific country. The calculated mean values have been used to estimate potential underestimation in those END agglomerations where noise contour maps were not available.

The results of the above describe calculations can be found in the resulting table accompanying this methodological report.

3.1.2 Agglomeration rail exposure estimation

The input data used for the analysis is the reported and gap filled exposure data as reported for the DF4_8 strategic noise maps, described in Blanes et al, 2023.

Based on the methodology described in Engelmann et al, 2023, noise exposure below the END threshold levels per each noise source have been estimated, and the population exposed to the different noise bands have been transferred from 5 dB to 1 dB band exposure distribution.

By using these results, and using the WHO thresholds (WHO Europe, 2018) for rail traffic noise, the number of people equal or above 54 dB Lden and 44 dB Lnight are estimated at city level.

For this source inside agglomerations, an extra analysis has been performed.

Based on the OpenStreetMap project (<https://www.openstreetmap.org/>), reference data for railways at country level can be downloaded from the portal geofabrik (<https://download.geofabrik.de/>).

Once downloaded, a selection of the railway classes to be included in the analysis has been undertaken based on the attribute "fclass": all rail segments classified as 'tram', 'rail' or 'light_rail' have been included in the analysis.

The resulting rail infrastructure have been overlayed with the noise contour maps provided at agglomeration level for rail traffic noise following the END specifications, to calculate percentage of the railway network covered by the noise contour maps.

If the percentage is below 100%, then it is assumed that not all existing railways have been included in the calculation of the number of people exposed to rail traffic noise, which could be a potential source of underestimation.

By using the percentage of railways covered per each agglomeration and the reported number of people exposed, the potential number of people exposed to rail traffic noise at agglomeration level is calculated using the following formula:

$$\text{People estimated} = (\text{People reported} * 100) / \text{Railways percentage}$$

Where:

People estimated corresponds to the exposed number of people estimated to rail traffic noise

People reported corresponds to the exposed number of people reported / gap filled to rail traffic noise under the END requirements

Railways percentage corresponds to the percentage of the railway network covered by noise contour maps inside the END agglomeration

The calculation has been undertaken considering both, the END threshold values as well as the WHO threshold values and for Lden and Lnight indicators.

However, the noise contour maps inside urban areas are only provided on voluntary basis by member countries. In the cases where this information is not available, a mean percentage have been calculated at country level if some END agglomerations reported noise contour maps, or a mean percentage at European level if any contour maps have been reported for any agglomeration in a specific country. The calculated mean values have been used to estimate potential underestimation in those END agglomerations where noise contour maps were not available.

The results of the above describe calculations can be found in the resulting table accompanying this methodological report.

3.1.3 Agglomeration air exposure estimation

The input data used for the analysis is the reported and gap filled exposure data as reported for the DF4_8 strategic noise maps, described in Blanes et al, 2023.

Based on the methodology described in Engelmann et al, 2023, noise exposure below the END threshold levels per each noise source have been estimated, and the population exposed to the different noise bands have been transferred from 5 dB to 1 dB band exposure distribution.

By using these results, and using the WHO thresholds (WHO Europe, 2018) for air traffic noise, the number of people equal or above 45 dB Lden and 40 dB Lnight are estimated at city level.

The results of this calculation can be found in the resulting table accompanying this methodological report.

3.2 Major road exposure estimation

The input data used for the analysis is the reported and gap filled exposure data as reported for the DF4_8 strategic noise maps, described in Blanes et al, 2023.

Based on the methodology described in Engelmann et al, 2023, noise exposure below the END threshold levels per each noise source have been estimated, and the population exposed to the different noise bands have been transferred from 5 dB to 1 dB band exposure distribution.

By using these results, and using the WHO thresholds (WHO Europe, 2018) for road traffic noise, the number of people equal or above 53 dB Lden and 45 dB Lnight are estimated at country level.

The results of this calculation can be found in the resulting table accompanying this methodological report.

3.3 Major rail exposure estimation

The input data used for the analysis is the reported and gap filled exposure data as reported for the DF4_8 strategic noise maps, described in Blanes et al, 2023.

Based on the methodology described in Engelmann et al, 2023, noise exposure below the END threshold levels per each noise source have been estimated, and the population exposed to the different noise bands have been transferred from 5 dB to 1 dB band exposure distribution.

By using these results, and using the WHO thresholds (WHO Europe, 2018) for rail traffic noise, the number of people equal or above 54 dB Lden and 44 dB Lnight are estimated at country level.

The results of this calculation can be found in the resulting table accompanying this methodological report.

3.4 Major air exposure estimation

The input data used for the analysis is the reported and gap filled exposure data as reported for the DF4_8 strategic noise maps, described in Blanes et al, 2023.

Based on the methodology described in Engelmann et al, 2023, noise exposure below the END threshold levels per each noise source have been estimated, and the population exposed to the different noise bands have been transferred from 5 dB to 1 dB band exposure distribution.

By using these results, and using the WHO thresholds (WHO Europe, 2018) for air traffic noise, the number of people equal or above 45 dB Lden and 40 dB Lnight are estimated at major airport level.

The results of this calculation can be found in the resulting table accompanying this methodological report.

4 Methodology to estimate exposure values for sources not included in the END

The estimations summarized in the next sections are focused on the areas not covered by the END reporting sources: roads outside urban areas below 3 million passes a year, railways outside urban areas below 30,000 passes a year, and airports outside urban areas below 50,000 movements a year.

The results of the calculation consider an estimation of the total number of people that would be exposed to noise levels if all sources (and not only the sources described in the END) would have been considered in the strategic noise maps. The percentage representing the exposed number of people versus the estimated number of people has been calculated at country level for road exposure and rail exposure.

In the case of aircraft exposure, the selection of the airports to be included in the analysis has been done based on expert knowledge, so the figures obtained at country level are not comparable, and results should only be evaluated at European level.

The proposed methodology in this case only includes calculations for the END noise reporting thresholds i.e. 55 dB Lden and 50 dB Lnight. An estimation of how many of those people are living in urban areas between 50,000 and 100,000 inhabitants is also provided.

4.1 Major roads and non-major roads exposure estimation

4.1.1 Input data

Source	Database	Link	Description
Major roads	gisco-ref-20180710.gdb	SDI data	EuroRegionalMap provides the first European geographic information infrastructure that will be maintained at the source level by the National Mapping Agencies, providing harmonised access conditions for geographic information (map scale 1:250 000).
	Selection of Primary roads, secondary roads and motorways, excluding Underground.		
Urban centres (> 50.000 inhabitants)	Bulgaria, Croatia	Geofabrik Download Server	OpenStreetMap (OSM) is a collaborative, open-source mapping project that provides free geographic data for Europe and the rest of the world.
	Selection of Primary roads, secondary roads and motorways excluding Underground.		
GISCO grid 1x1km with 2021 population	DG REGIO urban centres delineation	(not published)	<p>An urban centre consists of contiguous grid cells of 1 km², with the following characteristics:</p> <ul style="list-style-type: none"> • A population density of at least 1,500 inhabitants per km² of land. • A minimum total population of 50,000 inhabitants. • Gaps in the cluster are filled and edges are smoothed. <p>These datasets contain grid cells covering the land territory of the EU, with a resolution of 1km. Base statistics such as population figures are provided for these cells.</p>

4.1.2 Methodology

In order to estimate the exposure values for sources not included in the END, a selection of primary roads, secondary roads and motorways from the GISCO database have been undertaken for all EEA32 member countries with data available.

A buffer area based on the average distance values calculated from the END major roads to the noise contour maps delivered in 2022 for the main transport infrastructures have been calculated, distinguishing the major road source into 2 categories in relation to traffic data: road infrastructures with a traffic of 6 million vehicles and road infrastructures between 3 and 6 million vehicles. This traffic thresholds are the ones specified in the END.

The steps followed to calculate the average distance values of the noise contour maps to the noise source has been undertaken in another task and described in Blanes et al., 2024.

To estimate the average distance value, the maximum distance of the isophone representing the noise level of 55 dB Lden and the noise level of 50 dB Lnight to the noise source have been calculated, and a mean value has been obtained for Lden and for Lnight considering the different segments analysed in Blanes et al., 2024.

The average distance values applied to the selected roads from the GISCO database can be seen in Table 4.1.

Table 4.1. Distances applied

Noise source	END major road categories	GISCO road categories	Distance applied	
			Lden	Lnight
Roads	3-6 million vehicles	Primary and secondary roads	400 meters	230 meters
	>6 million vehicles	Motorways	1000 meters	650 meters

Once the buffer based on the distances from Table 4.1 is created, the result is overlaid with the population grid at 1 km². This overlay allows to calculate how many people could be potentially exposed to major and non major road traffic noise as the percentage of the grid area covered by the calculated buffer.

The obtained result at grid cell level is then summarized at country level, allowing to calculate how many people is in fact reported as exposed to road traffic noise compared to the potential number of people that would be exposed if all major and non major roads would be taken into account.

From the total potential number of people that would be exposed to road traffic noise, an estimation of how much people is living in urban centres between 50.000 and 100.000 inhabitants is calculated by overlaying the results with the Urban Centres from Urban Atlas 2018 (pre-selecting those urban centres with a population from 50.000 to 100.000 inhabitants).

The results obtained can be found in the resulting table accompanying this methodological report.

4.2 Major railways and non-major railways exposure estimation

4.2.1 Input data

Source	Database	Link	Description
Major rails	gisco-ref-20180710.gdb	SDI data	EuroRegionalMap provides the first European geographic information infrastructure that will be maintained at the source level by the National Mapping Agencies, providing harmonised access conditions for geographic information (map scale 1:250 000.)
	Bulgaria, Croatia	Geofabrik Download Server	OpenStreetMap (OSM) is a collaborative, open-source mapping project that provides free geographic data for Europe and the rest of the world.
Urban centres (> 50,000 inhabitants)	DG REGIO Urban Centres delineation	(not published)	<p>An urban centre consists of contiguous grid cells of 1 km², with the following characteristics:</p> <ul style="list-style-type: none"> • A population density of at least 1,500 inhabitants per km² of land. • A minimum total population of 50,000 inhabitants. • Gaps in the cluster are filled and edges are smoothed.
GISCO grid 1x1km with 2021 population	Geographic Information System of the Commission	https://ec.europa.eu/eurostat/web/gisco/geodata/grids	These datasets contain grid cells covering the land territory of the EU, with a resolution of 1km. Base statistics such as population figures are provided for these cells.

4.2.2 Methodology

In order to estimate the exposure values for sources not included in the END, a selection of major railways from the GISCO database have been undertaken for all EEA32 member countries with data available.

A buffer area based on the average distance values calculated from the END major railways to the noise contour maps delivered in 2022 for the main transport infrastructures have been calculated.

The steps followed to calculate the average distance values of the noise contour maps to the noise source has been undertaken in another task and described in Blanes et al., 2024.

To estimate the average distance value, the maximum distance of the isophone representing the noise level of 55 dB Lden and the noise level of 50 dB Lnight to the noise source have been calculated, and a mean value has been obtained for Lden and for Lnight considering the different segments analysed in Blanes et al., 2024.

The average distance values applied to the railway source from the GISCO database can be seen in Table 4.2.

Table 4.2. Distances applied

Noise source	END major rail category	GISCO rail category	Distance applied	
			Lden	Lnight
Rail	Major railway	Railway	1100 meters	650 meters

Once the buffer based on the distances from Table 4.2 is created, the result is overlaid with the population grid at 1 km². This overlay allows to calculate how many people could be potentially exposed to major and non major rail traffic noise as the percentage of the grid area covered by the calculated buffer.

The obtained result at grid cell level is then summarized at country level, allowing to calculate how many people is in fact reported as exposed to rail traffic noise compared to the potential number of people that would be exposed if all major and non major railways would be taken into account.

From the total potential number of people that would be exposed to rail traffic noise, an estimation of how much people is living in urban centres between 50.000 and 100.000 inhabitants is calculated by overlaying the results with the Urban Centres from Urban Atlas 2018 (pre-selecting those urban centres with a population from 50.000 to 100.000 inhabitants).

The results obtained can be found in the resulting table accompanying this methodological report.

4.3 Major airports and non-major airports exposure estimation

Although the concept followed to calculate the underestimated number of people exposed to major and non-major airports is the same as for the cases of major roads and major railways, this noise source is highly affecting the surrounding area of the airport and not the complete European territory.

In this case, the source data for the major and non major airports will not be the point location linked to the ICAO code of the airport, but the Corine Land Cover airport polygons (class 1.2.4) that correspond to the selected airports.

The selection of airports have been based on expert knowledge, and all airports above 20.000 movements per year from <https://ansperformance.eu/dashboard/stakeholder/airport/db/> (accessed on 10/07/2024) has been selected as part of the presented analysis.

The distance value applied to the CLC polygons selected is based on previous research compiled in Votsi et al. 2012, applying a buffer distance of 1500 meters for major airports and a buffer distance of 900 meters for non major airports.

Once the buffer based on the distances described in Votsi et al. 2012 is created, the result is overlaid with the population grid at 1 km². This overlay allows to calculate how many people could be potentially exposed to major and non major aircraft noise as the percentage of the grid area covered by the calculated buffer.

The obtained result at grid cell level is then summarized at country level, allowing to calculate how many people is in fact reported as exposed to Lden air traffic noise compared to the potential number of people that would be exposed if all major and non major airports would be taken into account.

It should be highlighted that although following the same approach as per major roads and major railways, the results obtained at country level are not comparable due to the selection of airports to be included. In some countries, no other airports than the major airports reported under the END have been selected to calculate the underestimation of the people exposed to major airport, which makes

the results obtained at country level not comparable. In this case, the only possible analysis of underestimation can be done at European level.

Comparing individual airports exposure from the reported (or gap filled) data with the data obtained from the presented analysis will not provide valuable results, as the buffer area around the CLC airport polygon may not represent the noise contour maps from the take-offs and landings that are used to calculate the number of people exposed to major aircraft noise.

Finally, as there is no information on the literature about buffer distances to be applied for aircraft noise for Lnight indicator, the estimation of the number of people exposed to aircraft noise (major and non-major airports) has been calculated applying the ratio between total number of people exposed to Lden and total number of people exposed to Lnight for those major airports reported under the END with less than 60.000 movements/year. The calculated ratio is 0,28 and has been applied to all selected airports with more than 20.000 movements/year.

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