NOISE POLLUTION

This document has been prepared by a group of experts under the "European Urban Mobility Observatory and Support" contract. It does not reflect or anticipate the position of the Commission. It does not constitute a legal proposal. The purpose of this document is to outline the indicators and the data required to calculate them, which the experts consider to be most appropriate for urban nodes to measure in the respective area. This document is intended to serve as a basis for reflection and further work on relevant indicators required by the TEN-T Regulation.

Data requirements

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
D1	I1 Total population of the city/FUA *[# inhabitants]*	Data on the size of the total population on 1st January	Cities, Offices for national or local statistics	n/a	Data collected every year	**Survey:** 93 city, 4 FUA, 113 both city and FUA 210 total at city and/or FUA level (98% of respondents)
D2	O1, O2, O3, Population of the city/FUA exposed to different day-evening-night (L_{den}) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to road/ rail/ air transport *[# inhabitants]*	**Preferred dataset** Data provided for Noise Observation and Information Service for Europe (END Directive, EEA dataset [7]) for agglomerations > 100,000 inhabitant	Cities, Province, Region, Member States	n/a	END Directive: every 5 years (published dataset for 2012, 2017, planned in 2022, 2027 and subsequently)	Road transport **Survey:** 87 city, 11 FUA, 14 both city and FUA 112 total at city and/or FUA level (52% of respondents) **EEA dataset:** 253 urban nodes in 2017 and 289 in 2012. In 2017, according to END, 17 urban nodes had no reporting obligations for road transport. Rail transport **Survey** 69 city, 8 FUA, 13 both city and FUA
		Alternative dataset 1 Methodology described in the Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council) / https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0996&from=EN	Cities, Province, Region, Member States	See methodology of alternative dataset 1		

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		Alternative dataset 2 Methodology described in the Annex on the basis of acoustic maps (L_{den}) and population distribution	Cities, Province, Region, Member States	GIS elaboration		90 total at city and/or FUA level (42% of respondents) **EEA dataset:** 247 urban nodes in 2017 and 282 in 2012. In 2017, according to END, 19 urban nodes had no reporting obligations for rail transport. Air transport **Survey:** 39 city, 7 FUA, 11 both city and FUA 57 total at city and/or FUA level (27% of respondents) **EEA dataset:** 99 urban nodes in 2017 and 128 in 2012. In 2017, according to END, 162 urban nodes had no reporting obligations for air transport.
D3	O4, O5, O6 Population of the city/FUA exposed to different night-time (L_{night}) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to road/ rail/ air transport *[# inhabitants]*	**Preferred dataset** Data provided for Noise Observation and Information Service for Europe (END Directive, EEA dataset [7]) for agglomerations > 100,000 inhabitant	Cities, Province, Region, Member States	n/a	END Directive: every 5 years (published dataset for 2012, 2017, planned in 2022, 2027 and subsequently)	Road transport **Survey:** 60 city, 5 FUA, 14 both city and FUA 79 total at city and/or FUA level (37% of respondents) **EEA dataset:** 253 urban nodes in 2017 and 289 in 2012. In 2017, according to END, 17 urban nodes had no reporting obligations for road transport. Rail transport **Survey:**
		Alternative dataset 1 Methodology described in the Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council) / https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0996&from=EN	Cities, Province, Region, Member States	See methodology of alternative dataset 1		

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		Alternative dataset 2 Methodology described in the Annex on the basis of acoustic maps (L_{night}) and population distribution	Cities, Province, Region, Member States	GIS elaboration		47 city, 5 FUA, 13 both city and FUA 65 total at city and/or FUA level (30% of respondents) **EEA dataset:** 247 urban nodes in 2017 and 282 in 2012. In 2017 according to END, 19 urban nodes had no reporting obligations for rail transport. Air transport **Survey:** 26 city, 5 FUA, 11 both city and FUA 42 total at city and/or FUA level (20% of respondents) **EEA dataset:** 97 urban nodes in 2017 and 116 in 2012. In 2017 according to END, 162 urban nodes have no reporting obligations for air transport.

Overview and analysis of data availability

Based on the analysis of responses to the urban mobility data and indicators survey, which was carried out in August-October 2023 and which collected responses from 215 urban nodes out of 430, the following considerations have been drawn for each dataset required for the indicators described below.

Summary and conclusions

From the aggregated results of the survey, it is observed that half of the respondents collect data on noise from road transport**.** Meanwhile, when looking at available data already reported under the END directive, it can be observed that two thirds of urban nodes provided data in 2012 and/or 2017. It would be beneficial to merge detailed data from both sources to have a complete overview. Regardless, even with the aggregated information available, it seems that a good level of availability could be achieved.

The alternative methodologies proposed build either directly on the Annex of the END directive or on intersecting noise maps and population distribution, allowing for comparability across the data and methodology. It is important to highlight that data is collected in some cases by environmental agencies/ departments and/or by authorities not related to city/FUA level, so cities might not be fully aware of availability or might not have direct access to this data (although the data is collected).

Similar conclusions can be drawn for noise related to rail transport, when looking at both the *urban mobility data and indicators* survey and EEA dataset (END directive): also in this case, about two thirds of urban nodes reported information.

Concerning noise related to air transport, it is crucial to consider that a large number of urban nodes are not affected since there are no airports or these are not located within their urban area. Therefore, lower absolute values do not necessarily correspond to lower availability of data. In this case, some respondents mentioned that data is collected by the related aviation authority or at airport level.

Altogether, a good level of overall data availability is estimated for the indicators above. Nevertheless, it should be noted that currently the END directive requires to collect this data every 5 years; therefore, the burden (and representativeness) of collecting the same information on an annual basis should be evaluated.

Detailed analysis

Please note that the figures provided do not always add up across questions, for example, in some cases respondents have replied only to the first of two related questions, or only to the second of two questions.

D1. (I1) Total population of the city/FUA [# inhabitants]

Survey results

- 210 respondents reported collection of/access to data "total number of inhabitants":
  - 98% of respondents
  - 93 at city level only, 4 at FUA level only, 113 at both city and FUA level.

D2. (O1) Population of the city/FUA exposed to different day-evening-night (Lden) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to road transport [# inhabitants]

Survey results

- 112 respondents reported collection of/access to data on exposure to day-evening-night (Lden) noise levels due to **road transport**
  - 52% of respondents
  - 87 at city level only, 11 at FUA level only, 14 at both city and FUA level

- *Note that the above numbers are reported for the second of two questions on noise pollution due to road transport. 108 cities responded to the first question (regarding data on exposure to LDen of 55-59 dB and of 60 dB or more), with a discrepancy of 4 cities with respect to the second question (regarding level at which data are collected). The cities responding to each question are not necessarily the same.*

Data from EEA dataset (END directive [7])

- According to EEA dataset, data is available in 253 urban nodes in 2017 and 289 in 2012. In 2017 according to END, 17 urban nodes had no reporting obligations for road transport.

(O2) Population of the city/FUA exposed to different day-evening-night (Lden) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to rail transport [# inhabitants]

Survey results

- 90 respondents reported collection of/access to data on exposure to day-evening-night (Lden) noise levels due to **rail transport**
  - 42% of respondents
  - 69 at city level only, 8 at FUA level only, 13 at both city and FUA level
  - *Note that the above numbers are reported for the second of two questions on noise pollution due to rail transport. 83 cities responded to the first question (regarding data on exposure to LDen of 55-59 dB and of 60 dB or more), with a discrepancy of 7 cities with respect to the second question (regarding level at which data are collected). The cities responding to each question are not necessarily the same.*

Data from EEA dataset (END directive [7])

- According to the EEA dataset, data is available in 247 urban nodes in 2017 and 282 in 2012 . In 2017 according to END, 19 urban nodes had no reporting obligations for rail transport.

(O3) Population of the city/FUA exposed to different day-evening-night (Lden) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to air transport [# inhabitants]

Survey results

- 57 respondents reported collection of/access to data on exposure to day-evening-night (Lden) noise levels due to **air transport**
  - 27% of respondents
  - 39 at city level only, 7 at FUA level only, 11 at both city and FUA level
  - *Note that the above numbers are reported for the second of two questions on noise pollution due to air transport. 47 cities responded to the first question (regarding data on exposure to LDen of 55-59 dB and of 60 dB or more), with a discrepancy of 10 cities with respect to the second question (regarding level at which data are collected). The cities responding to each question are not necessarily the same.*

Data from EEA dataset (END directive [7])

- According to the EEA dataset, data is available in 99 urban nodes in 2017 and 128 in 2012. In 2017, under the END directive 162 urban nodes had no reporting obligations for air transport. Not all urban nodes had reporting obligations according to the END directive.

D3. **(O4) Population of the city/FUA exposed to different night-time (Lnight) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to road transport** [# inhabitants]

Survey results

- 79 respondents reported collection of/access to data on exposure to night-time (Lnight) noise levels due to **road transport**
    - 37% of respondents
    - 60 at city level only, 5 only at FUA level only, 14 at both city and FUA level
    - *Note that the above numbers are reported for the second of two questions on noise pollution due to road transport. 104 cities responded the first question (regarding data on exposure to Lnight of 50-54 dB and of 55 dB or more), with a discrepancy of 25 cities with respect to the second question (regarding level at which data are collected). The cities responding to each question are not necessarily the same.*

Data from EEA dataset (END directive [7])

- According to the EEA dataset, data is available in 253 urban nodes in 2017 and 289 in 2012. In 2017 according to END, 17 urban nodes had no reporting obligations for road transport.

(O5) Population of the city/FUA exposed to different night-time (Lnight) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to rail transport [# inhabitants]

Survey results

- 65 respondents reported collection of/access to data on exposure to night-time (Lnight) noise levels due to **rail transport**
    - 30% of respondents
    - 47 at city level only, 5 only at FUA level only, 13 at both city and FUA level
    - *Note that the above numbers are reported for the second of two questions on noise pollution due to rail transport. 81 cities responded to the first question (regarding data on exposure to Lnight of 50-54 dB and of 55 dB or more), with a discrepancy of 16 cities with respect to the second question (regarding level at which data are collected). The cities responding to each question are not necessarily the same.*

Data from EEA dataset (END directive [7])

- According to the EEA dataset, data is available in 247 urban nodes in 2017 and 282 in 2012 . In 2017 according to END, 19 urban nodes had no reporting obligations for rail transport. Not all urban nodes had reporting obligations according to the END directive.

(O6) Population of the city/FUA exposed to different night-time (Lnight) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to air transport [# inhabitants]

Survey results

- 42 respondents reported collection of/access to data on exposure to night-time (Lnight) noise levels due to **air transport**

- 20% of respondents
- 26 at city level only, 5 only at FUA level only, 11 at both city and FUA level
- *Note that the above numbers are reported for the second of two questions on noise pollution due to air transport. 45 cities responded to the first question (regarding data on exposure to Lnight of 50-54 dB and of 55 dB or more), with a discrepancy of 3 cities with respect to the second question (regarding level at which data are collected). The cities responding to each question are not necessarily the same.*

Data from EEA dataset (END directive [7])

- According to the EEA dataset, data is available in 97 urban nodes in 2017 and 116 in 2012. In 2017, under the END directive 162urban nodes had no reporting obligations for air transport.

Survey: open-ended feedback

From the interpretation of the open-ended answers, it is reported that in 2 urban nodes data is collected by authorities at provincial level, in 9 urban nodes at regional level, in 13 at national level. Furthermore, 10 urban nodes underlined that data related to noise are collected by Environmental agencies or departments. Finally, some respondents (4) mentioned that data related to air transport noise is collected by the related aviation authority or at airport level. Concerning the availability of any other type of data to monitor noise pollution, the following data were reported: questionnaires and survey on noise perception/disturbance (6 cities) monitoring of noise pollution in specific sites of the city (4 cities).

Comment: Road/rail/air transport combined

The survey question considered two levels of noise for Lden (50-54 dB and ≥55dB). Based on the assumption that any noise data measurement is likely to include measurement of a wide range of/all noise levels, it is assumed for the purpose of the proposed indicators that positive answers on data availability for these two options are representative also for the other ranges required by the END directive. Note that the answers to the two ranges of Lnight were not always the same: when reporting below the positive answers on data availability, the lower of the values has been considered.

Indicators

Number	Indicator	To be calculated by:
	Input indicators	
I1	Total population of the city/FUA *[# inhabitants]*	Urban node
	Output indicators	
O1	Population of the city/FUA exposed to different day-evening-night (L_{den}) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to road transport *[# inhabitants]*	Urban node

O2	Population of the city/FUA exposed to different day-evening-night (L_{den}) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to rail transport *[# inhabitants]*	Urban node
O3	Population of the city/FUA exposed to different day-evening-night (L_{den}) noise levels (55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB, ≥75 dB) due to air transport *[# inhabitants]*	Urban node
O4	Population of the city/FUA exposed to different night-time (L_{night}) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to road transport *[# inhabitants]*	Urban node
O5	Population of the city/FUA exposed to different night-time (L_{night}) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to rail transport *[# inhabitants]*	Urban node
O6	Population of the city/FUA exposed to different night-time (L_{night}) noise levels (50-54 dB, 55-59 dB, 60-64 dB, 65-69 dB, ≥70 dB) due to air transport *[# inhabitants]*	Urban node
	Result indicators	
R1	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥55 dB due to road transport *[% of inhabitants]*	EC
R2	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥55 dB due to rail transport *[% of inhabitants]*	EC
R3	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥55 dB due to air transport *[% of inhabitants]*	EC
R4	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥60 dB due to road transport *[% of inhabitants]*	EC
R5	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥60 dB due to rail transport *[% of inhabitants]*	EC
R6	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥60 dB due to air transport *[% of inhabitants]*	EC
R7	Percentage of population of the city/FUA exposed to night-time (L_{night}) noise ≥50 dB due to road transport *[% of inhabitants]*	EC
R8	Percentage of population of the city/FUA exposed to night-time (L_{night}) noise ≥50 dB due to rail transport *[% of inhabitants]*	EC
R9	Percentage of population of the city/FUA exposed to night-time (L_{night}) noise ≥50 dB due to air transport *[% of inhabitants]*	EC
R10	Population of the city/FUA highly annoyed (HA) due to road transport noise *[# inhabitants]*	EC
R11	Population of the city/FUA highly annoyed (HA) due to rail transport noise *[# inhabitants]*	EC
R12	Population of the city/FUA highly annoyed (HA) due to air transport noise *[# inhabitants]*	EC

R13	Percentage of population of the city/FUA highly annoyed (HA) due to road transport noise *[% of inhabitants]*	EC
R14	Percentage of population of the city/FUA highly annoyed (HA) due to rail transport noise *[% of inhabitants]*	EC
R15	Percentage of population of the city/FUA highly annoyed (HA) due to air transport noise *[% of inhabitants]*	EC

Method of calculation of result indicators

Please note that the equations below could be applied centrally at European level to calculate the values of the result indicators based on input and output data provided by the urban nodes under the input and output indicators.

#	**Method name** (component of indicator)	**Indicator(s)**	**Equation**	**Variables**
M1	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥55 dB due to road/ rail/ air transport *[% of inhabitants]*	R1, R2, R3	$NE_m^{Lden \geq 55} = \frac{\sum_i P_{im}^{Lden}}{P}$	- $NE_m^{Lden \geq 55}$ = Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥55 dB due to transport mode m (road/ rail/ air) *[%]* - P_{im}^{Lden} = Population of the city/FUA exposed to day-evening-night (L_{den}) noise band i (where i ≥55 dB) for transport mode m (road/ rail/ air) *[# inhabitants]* Indicator O1, O2, O3 (data D2). - i = L_{den} noise band *[dB]* - P = Total population of the city/FUA *[# inhabitants].* Indicator I1.
M2	Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥60 dB due to road/ rail/ air transport *[% of inhabitants]*	R4, R5, R6	$NE_m^{Lden \geq 60} = \frac{\sum_i P_{im}^{Lden}}{P}$	- $NE_m^{Lden \geq 60}$ = Percentage of population of the city/FUA exposed to day-evening-night (L_{den}) noise ≥60 dB due to transport mode m (road/ rail/ air) *[%]* - P_{im}^{Lden} = Population of the city/FUA exposed to day-evening-night (L_{den}) noise band i (where i ≥60 dB) for transport mode m (road/ rail/ air) *[# inhabitants]*. Indicator O1, O2, O3 (data D2). - i = L_{den} noise band *[dB]* - P = Total population of the city/FUA *[# inhabitants].* Indicator I1.

#	**Method name** (component of indicator)	**Indicator(s)**	**Equation**	**Variables**
M3	Percentage of population of the city/FUA exposed to night-time (L_{night}) noise ≥50 dB due to road/ rail/ air transport *[% of inhabitants]*	R7, R8, R9	$NE_m^{Lnight} = \frac{\sum_i P_{im}^{Lnight}}{P}$	- NE_m^{Lnight} = Percentage of population of the city/FUA exposed to night-time (L_{night}) noise ≥50 dB due to transport mode m (road/ rail/ air) *[%]* - P_{im}^{Lnight} = Population of the city/FUA exposed to night-time (L_{night}) noise band i (where i ≥50 dB) for transport mode m (road/ rail/ air) *[# inhabitants].* Indicator O4, O5, O6 (data D3). - i = L_{night} noise band *[dB]* - P = Total population of the city/FUA *[# inhabitants].* Indicator I1.
M4	Population of the city/FUA highly annoyed due to road/ rail/ air transport noise *[# inhabitants]*	R10, R11, R12	$P_m^{HA} = \sum_i W_{im}^{HA} * P_{im}^{Lden}$	- P_m^{HA} = Population of the city/FUA Highly Annoyed due to L_{den} noise by transport mode m (road/ rail/ air) *[# inhabitants]* - W_{im}^{HA} = High Annoyance weight factor for transport mode m (rail/ road/ air) and noise band i (where i ≥55 dB) *[%]* - P_{im}^{Lden} = Population of the city/FUA exposed to day-evening-night (L_{den}) noise band i (where i ≥55 dB) for transport mode m (road/ rail/ air) *[# inhabitants].* Indicator O1, O2, O3 (data D2). - i = L_{den} noise band *[dB]*
M5	Percentage of population of the city/FUA highly annoyed due to road/ rail/ air transport noise *[% of inhabitants]*	R13, R14, R15	$NI_m^{HA} = \frac{\sum_i W_{im}^{HA} * P_{im}^{Lden}}{P}$	- NI_m^{HA} = Percentage of population of the city/FUA highly annoyed due to L_{den} noise by transport mode m (road/ rail/ air) *[%]* - W_{im} = High Annoyance weight factor for transport mode m (rail/ road/ air) and noise band i (where i ≥55 dB) *[%]* - P_{im}^{Lden} = Population of the city/FUA exposed to day-evening-night (L_{den}) noise band i (where i ≥55 dB) for transport mode m (road/ rail/ air) *[# inhabitants].* Indicator R10, R11, R12. - i = L_{den} noise band *[dB]* - P = Total population of the city/FUA *[# inhabitants].* Indicator I1.

Definitions of terms and acronyms used

Term	Definition	Source(s)
Agglomeration	A part of a territory, delimited by the Member State, having a population in excess of 100,000 persons and a population density such that the Member State considers it to be an urbanised area.	- Article 3 of the Environmental Noise Directive (END) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:189:FULL&from=EN
Air transport environmental noise	Noise levels due to aircrafts inside an agglomeration. The noise at points on the ground from aircraft flying into and out of a nearby aerodrome depends on many factors. Principal among these are the types of aeroplane and their powerplant; the power, flap and airspeed management procedures used on the aeroplanes themselves; the distances from the points concerned to the various flight paths; and local topography and weather.	- Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council), ANNEX - ASSESSMENT METHODS FOR THE NOISE INDICATORS, pages 44 – 51: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0996&from=EN
A-weighting of average sound level	Decibels with the sound pressure scale adjusted to conform with the frequency response of the human ear. A sound level meter that measures A-weighted decibels has an electrical circuit that allows the meter to have the same sensitivity to sound at different frequencies as the average human ear. It is the most commonly used of the series of curves defined in the international standard IEC 61672:2003 and various national standards for the measurement of sound pressure levels.	- EEA glossary: https://www.eea.europa.eu/help/glossary/eea-glossary/a-weighted-decibel
City	A city is a local administrative unit where at least 50 % of the population lives in one or more urban centres (i.e., a cluster of contiguous grid cells of 1 km² - excluding diagonals - with a population density of at least 1,500 inhabitants per km² and collectively a minimum population of 50,000 inhabitants after gap-filling).	- Eurostat glossary (webpage): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Category:Regions_and_cities_glossary
Decibel (dB)	Unit of measurement of noise level, based on a logarithmic scale used to denote the intensity, or pressure level, of a sound relative to the threshold of human hearing.	- EEA glossary: https://www.eea.europa.eu/help/glossary/eea-glossary/decibel

Term	Definition	Source(s)
Environmental noise	Unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport such as road traffic, rail traffic, and air traffic, and from sites of industrial activity such as those defined in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control.	- Article 3 of the Environmental Noise Directive (END): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:189:FULL&from=EN
Functional urban area (FUA)	A functional urban area consists of a densely inhabited city and a less densely populated commuting zone whose labour market is highly integrated with the city.	- Eurostat glossary (webpage): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Category:Regions_and_cities_glossary
High Annoyance weight factor for air transport	The parameters resulting from the "dose-effect relation" representing the relationship between the value of a noise indicator and a harmful effect. The relation provides the high annoyance level related to L_{den} values for air transport. For each L_{den} noise band, the average noise level is used as reference (e.g., for noise band 55-59 dB, the value of 57.5 dB is used). The relation for air transport is: $\%HA = -50.9693 + 1.0168 \times L_{den} + 0.0072 \times L_{den}^{2}$ Therefore, the following values are used for each noise band: - 55-59 dB: 31.3% - 60-64 dB: 40.7% - 65-69 dB: 50.5% - 70-74 dB:60.6% ≥75 dB: 71.1%	- WHO, Environmental noise guidelines for the European Region; 2018, page 69: https://www.who.int/europe/publications/i/item/9789289053563 - Commission Directive (EU) 2020/367 of 4 March 2020 amending Annex III to Directive 2002/49/EC of the European Parliament and of the Council as regards the establishment of assessment methods for harmful effects of environmental noise: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L0367
High Annoyance weight factor for rail transport	The parameters resulting from the "dose-effect relation" representing the relationship between the value of a noise indicator and a harmful effect. The relation provides the high annoyance level related to L_{den} values for rail transport. For each L_{den} noise band, the average noise level is used as reference (e.g., for noise band 55-59 dB, the value of 57.5 dB is used). The relation for rail transport is: $\%HA = 38.1596 - 2.05538 \times L_{den} + 0.0285 \times L_{den}^{2}$ Therefore, the following values are used for each noise band: - 55-59 dB: 14.2%	- WHO, Environmental noise guidelines for the European Region; 2018, page 54: https://www.who.int/europe/publications/i/item/9789289053563 - Commission Directive (EU) 2020/367 of 4 March 2020 amending Annex III to Directive 2002/49/EC of the European Parliament and of the Council as regards the establishment of assessment methods for harmful effects of environmental noise: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L0367

Term	Definition	Source(s)
	- 60-64 dB: 21.0% - 65-69 dB: 29.3% - 70-74 dB:38.9% ≥75 dB: 50.0%	
High Annoyance weight factor for road transport	The parameters resulting from the "dose-effect relation" representing the relationship between the value of a noise indicator and a harmful effect. The relation provides the high annoyance level related to L_{den} values for road transport. For each L_{den} noise band, the average noise level is used as reference (e.g., for noise band 55-59 dB, the value of 57.5 dB is used). The relation for road transport is: $\%HA = 78.9270–3.1162 \times L_{den} + 0.0342 \times L_{den}^{2}$ Therefore, the following values are used for each noise band: - 55-59 dB: 12.8% - 60-64 dB: 17.8% - 65-69 dB: 24.4% - 70-74 dB:32.8% - ≥75 dB: 42.8%	- WHO, Environmental noise guidelines for the European Region; 2018, page 39: https://www.who.int/europe/publications/i/item/9789289053563 - Commission Directive (EU) 2020/367 of 4 March 2020 amending Annex III to Directive 2002/49/EC of the European Parliament and of the Council as regards the establishment of assessment methods for harmful effects of environmental noise: - https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L0367
Highly annoyed population	- The part of the population particularly annoyed by day-evening-night (L_{den}) noise levels, as estimated by applying the High Annoyance weight factors. See "Noise Annoyance" definition. It shall mean the degree of community noise annoyance as determined by means of field surveys.	- Article 3(c) of the Environmental Noise Directive (END): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:189:FULL&from=EN
L_{den} (day-evening-night level of noise)	A long-term average noise indicator designed to assess overall annoyance and defined by the END. It refers to an A-weighted average sound pressure level over all days, evenings, and nights in a year. The day-evening-night level L_{den} in decibels (dB) is defined by the following formula: $L_{den} = 10\lg\frac{1}{24}\left(12*10^{\frac{L_{day}}{10}} + 4*10^{\frac{L_{evening}+5}{10}} + 8*10^{\frac{L_{night}+10}{10}}\right)$ in which:	- Article 3 and Annex I of the Environmental Noise Directive (END): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:189:FULL&from=EN

Term	Definition	Source(s)
	— L_{day} is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the day periods of a year, — $L_{evening}$ is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the evening periods of a year, — L_{night} is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year. The day is counted as 12 hours, the evening four hours, and the night eight hours. The Member States may shorten the evening period by one or two hours and lengthen the day and/or the night period accordingly, provided that this choice is the same for all the sources and that they provide the Commission with information on any systematic difference from the default option. The start of the day (and consequently the start of the evening and the start of the night) shall be chosen by the Member State (that choice shall be the same for noise from all sources); the default values are 07.00 to 19.00, 19.00 to 23.00 and 23.00 to 07.00 local time.	
L_{night} (night-time level of noise)	A long-term average noise indicator defined by the END and designed to assess sleep disturbance. The night-time noise indicator L_{night} is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year. The night is eight hours; the start of the night shall be chosen by the Member State: the default values are 23.00 to 07.00 local time.	- Article 3 and Annex I of the Environmental Noise Directive (END): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:189:FULL&from=EN
Noise annoyance	A feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound. In the current WHO guidelines, “annoyance” refers to long-term noise annoyance.	- WHO, Environmental noise guidelines for the European Region (2018), page 11: https://www.who.int/europe/publications/i/item/9789289053563
Noise band	Each range of 5 dB into which the noise levels are grouped (e.g., 50-54 dB, 55-59 dB, etc.). It refers to bands of values of L_{den} or L_{night} in dB estimated 4 m above the ground on the most exposed façade of the dwelling under consideration.	- Annex VI of the Environmental Noise Directive (END): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:189:FULL&from=EN

Term	Definition	Source(s)
Noise Observation and Information Service for Europe	The noise exposure information dataset provided under the END Directive (2002/49/EC) and published by the European Environmental Agency (EEA).	- European Environmental Agency (EEA) – Noise data reported under Environmental Noise Directive (END): https://www.eea.europa.eu/data-and-maps/data/data-on-noise-exposure-8
Rail transport environmental noise	Noise levels generated by rail traffic on railway infrastructure inside an agglomeration. For the purposes of this noise calculation method, 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 (consisting of a series of coupled vehicles).	- Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council), pages 12-13: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0996&from=EN
Road transport environmental noise	Noise levels generated by road traffic on road infrastructure inside an agglomeration. The road traffic noise source shall be determined by combining the noise emission of each individual vehicle forming the traffic flow.	- Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council), page 5: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0996&from=EN
Total population	The total number of inhabitants (usual resident population) of a given area (functional urban area or city): the number of inhabitants on 1st January of the year in question (or, in some cases, on 31st December of the previous year).	- Eurostat glossary (webpage): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Population_figure

ANNEX: Methodology to estimate population of the city/FUA exposed to environmental noise generated by road, rail, and air transport

The below methodology is proposed in case the urban node is not required to report (and does not collect) data as described in the Environmental Noise Directive (END) (“Alternative dataset 2”).

Input data

The input data reported in the following table is required.

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
A1	Acoustic map (L_{den}) of the city/FUA related to road, rail, air transport	A noise map designed for the assessment of noise exposure with the L_{den} (day-evening-night noise) indicator in a given area due to different noise sources (road, rail, air transport)	Cities, Local Authorities		As in "Data requirements" table	
A2	Acoustic map (L_{night}) of the city/FUA related to road, rail, air transport	A noise map designed for the assessment of noise exposure with the L_{night} (night noise) indicator in a given area due to different noise sources (road, rail, air transport)	Cities, Local Authorities		As in "Data requirements" table	
A3	Spatial distribution of the population in the city/FUA	- Spatial distribution of population from local statistical offices - Global Human Settlement Layer (GHSL) containing city-level population data at 250 m grid cell level for 2015 - JRC-GEOSTAT 2018 database could be used as supporting data if needed. It contains data on the number of residents for the year 2018 for Europe with regular grid map of 1 x 1 km cells	Cities, Local authorities, Eurostat		As in "Data requirements" table	Examples / Alternative options: - https://ghsl.jrc.ec.europa.eu/data.php - https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/geostat

Description

The objective is to calculate the population exposed to road, rail, and air transport noise in the following noise bands:

- L_{den}: <55 dB, 55–59 dB, 60–64 dB, 65–69 dB, 70–74 dB and ≥75 dB
- L_{night}: <50 dB, 50–54 dB, 55–59 dB, 60–64 dB, 65–69 dB and ≥70 dB

To estimate the population exposed in each noise band, the following two datasets must be combined for each mode (road, rail, air transport) and indicator (L_{den}, L_{night}):

1) the spatial distribution of the population in the city/FUA;

2) the acoustic maps (L_{den}, L_{night}) of the city/FUA related to road, rail, and air transport.

The procedure requires a GIS elaboration. The population exposed to noise related to a specific transport mode (road, rail, air transport) is calculated separately for each noise band: the Intersect Tool[1] is applied to overlap the population spatial distribution layer with the related acoustic maps (reporting the defined noise bands). The intersection with population is required separately for each noise indicator (L_{den}, L_{night}), each transport mode, and each noise band.

Hence, the process is required to be performed separately for each of the 6 indicators to be estimated: O1, O2, O3, O4, O5, O6 (with the related spatial definition for city/Urban Functional Area).

Subsequently, data is aggregated (i.e. summed) at city/Urban Functional Area level to estimate the population exposed to the defined noise bands by transport mode.

[1] The Intersect Tool performs a geometric overlap. All features that overlap intersecting layers will be part of the output feature class.