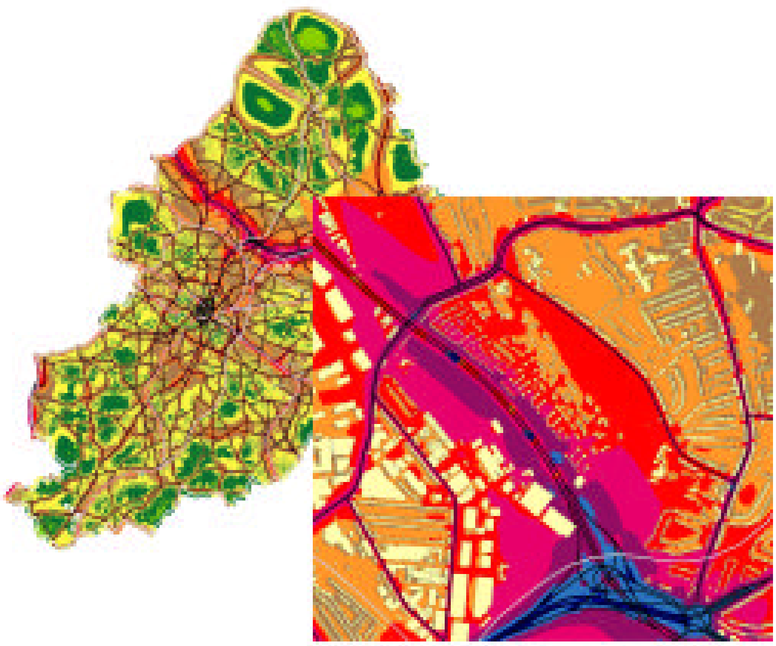
European Commission Working Group
Assessment of Exposure to Noise
(WG-AEN)



Position Paper

Final Draft

Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure

Version 2

13th January 2006

Contents **Page**

Chapter 1. Introduction

1.1 This is Version 2 of a Position Paper that has been produced by the European Commission's Working Group - Assessment of Exposure to Noise (WG-AEN), and replaces Version 1, which was published on the 5th December 2003 (Ref.1) and was the subject of a pan European consultation process. Version 1 has been revised, modified and enhanced to take account of the feedback from the consultation process and recent developments, including the results of a research project sponsored by the United Kingdom (UK) Government (see section 1.6 for further details). **Readers of this Version 2, hereinafter referred to as the or this 'Position Paper', should note that there are significant changes between this Position Paper and Version 1,** for example the way that the issue of assigning noise levels to buildings is dealt with. (This is one of the most important alterations that have resulted from the consultation process.)

1.2 The purpose of this Position Paper is to help Member States and their competent authorities undertake noise mapping and produce the associated data as required by Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise (commonly known as the Environmental Noise Directive and hereinafter referred to as 'the END'). **It is hoped that the content of this Position Paper will be particularly helpful for the first round of strategic noise mapping, which must be completed by 30 June 2007.** It is not meant to be a manual for strategic noise mapping but provides advice on specific issues that were raised initially by Member States and more recently through consultation on Version 1. Some of these issues are quite complicated and have been dealt with in detail. Other issues are less complicated and have been addressed accordingly.

1.3 It is not the purpose of this Position Paper to make recommendations on action planning required under the END. However, the reader should bear in mind that, according to the END, action plans must be based upon the results of strategic noise maps and must apply to the most important areas as established by strategic noise mapping. WG-AEN believes that more detailed noise modelling/mapping and noise exposure assessment may have to be undertaken in order to produce detailed local action plans.

1.4 It is not the purpose of this Position Paper to assist noise mapping software designers to develop software and systems that are consistent with the requirements of the END. Neither is it intended to address in detail the role of Geographical Information Systems (GIS) in noise mapping and the production of associated data although WG-AEN recognises the importance of GIS in relation to the processing and management of data. Consequently, this Position Paper includes an introduction to the subject of GIS in Appendix 2.

1.5 A particular challenge for WG-AEN in preparing this Position Paper has been to consider how much guidance it should provide. WG-AEN has attempted to find an appropriate balance between the need for a consistent approach across Europe and the flexibility required by individual Member States to develop noise-mapping programmes that meet their own national needs.

1.6 The content of this Position Paper is as follows:

- **Chapter 2,** which provides discussions on, and some recommendations for, dealing with general issues and noise source, noise propagation and receiver related issues that have been raised by the END (see also Chapter 4);

- **Chapter 3,** which provides an introduction to, and discussion on, the implications for accuracy of using the toolkits provided in Chapter 4. This is based on the results of a UK Government sponsored research project, referred to in Section 1.1, entitled 'WG-AEN's Good Practice Guide And The Implications For Acoustic Accuracy' (Ref. 2) [1], hereinafter generally referred to as the 'Accuracy Study';

- **Chapter 4,** which provides 21 toolkits most of which supplement recommendations given in Chapter 2. Six of these toolkits are new having been produced through the Accuracy Study [1]; and

- A series of appendices, most notably Appendix 4 and Appendix 5 which are based on the results of the Accuracy Study [1] and deal with understanding sources of uncertainty in noise modelling and the importance of data for strategic noise mapping.

1.7 WG-AEN would like to emphasise that the toolkits contained in Chapter 4 provide <u>examples</u> for dealing with issues arising from the END and, in particular, shortfalls in data availability and quality.

1.8 WG-AEN strongly recommends that every effort should be made to obtain accurate real data on noise sources. However, where data has to be estimated because accurate real data cannot be obtained, the methods/solutions (the tools), provided in toolkits in Chapter 4, can be used.

[1] For a full appreciation of the results of the Accuracy Study please consult all the reports relating to this Study (Ref.2). **Caution**. It should be borne in mind that the Accuracy Study focuses on the recommended interim road traffic noise method, which is the French national method (Ref.3), and the UK national road traffic noise calculation method CRTN (Ref.4). It may not always be possible to apply the results to other methods.

1.9 Requests for information on the content of the END should be sent by mail to:

European Commission
Environment DG
Information Centre
BU-9 01/11
B - 1049 Brussels
Belgium

Or by e-mail to: env-europa@cec.eu.int

Requests for information on the content of this Position Paper should be sent by e-mail to:

goodpracticeguide2@dsl.pipex.com

For further information on environmental noise issues in general please visit the following website:

http://forum.europa.eu.int/Public/irc/env/noisedir/library

IMPORTANT NOTE

The content of this Position Paper is intended to assist Member States in understanding and fulfilling the requirements of Directive 2002/49/EC (the END) by making technical recommendations on noise mapping practicalities and to remind the reader of some of the most important provisions of the Directive concerning strategic noise mapping.

This Position Paper should not be considered as an official statement of the position of the European Commission.

Only the text of the Directive is applicable in law. If, in any circumstance, the recommendations contained in this guide seem to be at variance with the Directive then the text of the Directive must be applied.

Chapter 2. Issues raised by the END

General Issues

2.01 Strategic noise maps (and mapping)

Formal END Definition:

Article 3 (r)

'strategic noise map' shall mean a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area;

Discussion 1

The acquisition of input data (particularly source related and geographic) required for the purposes of strategic noise mapping and the production of exposure data will be a major task for Member States. In some instances it may be impractical for a Member State to obtain real data i.e. data that has been measured directly or has been estimated using modelling techniques.

WG-AEN's recommendations 1

WG-AEN recommends that Member States use the advice contained in the remainder of this Chapter and in the toolkits, provided in Chapter 4, to address and resolve data acquisition issues in the first round of strategic noise mapping.

Discussion 2

The purpose of strategic noise mapping is primarily threefold; to provide the European Commission (EC) with strategic estimates of noise exposure across Europe to assist in the future development of European noise policy, to provide information to the public and decision makers on noise exposure locally, nationally and internationally and finally, to develop action plans. However, the use of the terms 'strategic noise maps' and 'global assessment' in the formal definition can be taken to imply that a certain amount of approximation may be made in the production of these maps and the associated data on noise exposure. This is unlikely to cause any significant difficulties in providing global assessments of noise exposure for the EC and for providing the public with suitable data in the form of maps or tables. However, it may cause difficulties in developing the detailed and local aspects of action plans.

WG-AEN's recommendations 2

WG-AEN recommends that for strategic noise mapping some approximations in relation to the assignment of noise levels to residential buildings, the assignment of the population to residential buildings and in the determination of the exposure to noise of people living in these residential buildings should be accepted. Some examples of good practice in respect of making such approximations are provided in turn in Sections 2.44, 2.45, and 2.47 and in associated Toolkits 19, 20 and 21.

2.02 Assessment methods

Issue

Annex II (1) of the END indicates that values of L_{den} and L_{night} can be determined by computation or measurement methods (at the assessment position).

Discussion

The measurement of the yearly average noise levels at all the assessment positions required by the END, or at a representative number of such positions is likely to require an impractically large number of long-term noise measurements. Furthermore, as indicated in Annex II (1) of the END, when predicting the effects of proposed actions on noise levels, only computation methods are applicable. This means that if noise mapping is carried out by measurement it will be difficult to fully evaluate the impact of proposed action plans or new developments.

WG-AEN's recommendations

The END permits the use of noise measurement for strategic noise mapping and it would be inappropriate for WG-AEN to recommend that noise measurement should not be used for this purpose. Nevertheless, WG-AEN encourages Member States to undertake strategic noise mapping for the END using computation methods wherever possible. WG-AEN recognises that some noise measurement is essential to the development and validation of computation methods. It also has a role to play in other aspects of the implementation of the END (see section 2.03).

2.03 The role of noise measurement

Issue

In Annex II (1) it is stated that (for the purpose of strategic noise mapping) values of L_{den} and L_{night} can be determined either by computation or by measurement (at the assessment positions) and that for prediction, only computation is applicable.

Discussion

To carry out the strategic noise mapping required by the END by measurement is problematic as it is generally impractical to measure at a sufficient number of positions for a sufficiently long period of time to be representative of an average year over the large areas involved with sufficient

degree of resolution. Also, the results so obtained cannot be used to predict the effects of proposed action plans (see also section 2.02).
However, noise measurements may be used to validate noise maps at selected sites, boost public confidence in these maps, help develop detailed action plans and to show the real effects of action plans once they are implemented.
Noise measurements may also be needed to determine emission levels or base levels to be extrapolated by calculation, for example, from industrial processes.

WG-AEN's Recommendations

WG-AEN recommends that wherever possible strategic noise mapping should generally be carried out by computation. However, it is recognised that noise measurement has many supplementary roles to play in the effective implementation of the END.

2.04 Area to be mapped

Issue

In the case of agglomerations the area to be noise mapped is the agglomeration as defined by a Member State. In the case of major roads, railways and airports the situation is less clear as Article 8 (1) requires that action plans (and thus strategic noise maps) should be drawn up for places **near** major roads, major railways, and major airports.

Discussion

*The definition of **near** needs to be based on the requirements for data to be sent to the Commission (see Annex VI (1.5), (1.6), (2.5), (2.6) of the END). Therefore, in the case of major roads, railways and airports, both inside and outside agglomerations, strategic noise mapping has to be carried out for at least all areas where the L_{den} from major roads, railways or airports is equal to or greater than 55dB and for all areas where the L_{night} from major roads, railways or airports is equal to or greater than 50dB.*

WG-AEN's recommendation

WG-AEN recommends that Toolkit 1 is used to determine the area to be mapped around major roads, major railways and major airports.

2.05 Sources outside the agglomeration area being mapped (how far out to search for additional sources)

Issue

When noise mapping an agglomeration, whilst only the area of the agglomeration has to be mapped, some noise sources outside the agglomeration boundary may have significant noise impacts within the agglomeration.

Discussion

Some roads, railways, industry and aircraft landing at or taking off from airports, which are located outside the boundary of an agglomeration, may contribute significantly to noise levels within the agglomeration. Such sources have to be considered and modelled when noise mapping an agglomeration. This is a complicated issue as there are many possible situations that may require different approaches. In addition, the cost of strategic noise mapping will be greatly influenced by the size of the area being modelled.

The key question is 'is noise from the source in question likely to cause an increase in noise levels within the agglomeration'. To answer this question consideration will have to be given to the sound power or sound pressure levels produced by these sources, their cumulative effect, meteorological conditions, topography, distance between the sources and the agglomeration and the noise level within the agglomeration produced from other noise sources.

WG-AEN's recommendations

WG-AEN is unable to provide definitive recommendations on this complicated issue as such recommendations could not cover all situations that will arise in practice, however, with due consideration of the issues discussed above, it should be possible to make a rough estimate as to what will or will not impact on an agglomeration. Consideration could also be given to approximating the 55dBL_{den} and the 50dBL_{night} noise contours produced by individual sources that are outside an agglomeration. If it appears that these contours will fall within an agglomeration then generally the sources in question should be considered in a noise mapping exercise.

2.06 Relevant year as regards the emission of sound

Issue 1

Annex I (1) of the END states that, for the purpose of the assessment of L_{den} and L_{night}, '**a year is a relevant year as regards the emission of sound** and an average year as regards the meteorological circumstances.'

Discussion 1

The above provision of the END means that different time averaging needs to be used to assess the emission of sound and the meteorological conditions (see 2.07) for the purpose of calculating the L_{den} and L_{night} indicators required for strategic noise mapping.

WG-AEN's recommendations 1

WG-AEN recommends that the data used to assess sound emissions and thereby carry out strategic noise mapping (i.e. mainly traffic volumes, speeds, and flow compositions for transport noise) should reflect the average calculated over the continuous period of twelve months of a relevant *calendar* year (January to December).

WG-AEN believes that this data may be real data (measured during a relevant *calendar* year) or data produced from forecasting or modelling techniques provided these are averages reflecting the situation in a relevant *calendar* year.

Issue 2

Article 7 (1) of the END indicates that the strategic noise maps must show the situation in the 'preceding calendar year'. However, Annex IV (1) indicates that strategic noise maps may present data on an existing, a previous or a predicted situation.

Discussion 2

In view of the above further advice on the relevant situations (years) to consider for carrying out strategic noise mapping to comply with the END may be beneficial.

WG-AEN's recommendations 2

In order to comply with requirements laid down in Article 7 (1), WG-AEN believes that the first round of strategic noise maps must at least show the situation for 2006 (while the second round must show at least the situation for 2011, and so on).

However, WG-AEN acknowledges that other situations (years) – past or future – may also be shown as suggested by Annex IV (1) leaving flexibility with Member States in this respect.

WG-AEN believes that this approach could result in the provision of better information to the public and thus secure their involvement, given that they must be consulted on proposals for action plans. In this respect, it might be relevant to show future situations, and differences between current and future situations, corresponding to, for example, the effects of different proposals for action plans on which the public would be invited to comment.

2.07 Average year as regards the meteorological circumstances

Issue

Annex I (1) of the END states that, for the purpose of the assessment of L_{den} and L_{night}, '**a year is** a relevant year as regards the emission of sound and **an average year as regards meteorological circumstances**'.

Discussion

The meteorological year is a continuous 12-month period (from the beginning of January to the end of December) comprising all 4 seasons but excluding periods when weather conditions that are considered particularly extreme for a specific area occur in that area. An ***average year*** *has to be determined by averaging several meteorological years. The question is how many?*

WG-AEN's recommendations

WG-AEN recommends that ideally, the required meteorological data should be acquired from measurements e.g. within the agglomeration or near to the major source to be mapped. If this is not possible, measurements from a nearby site that is meteorologically representative[2] of the site of interest may be used. To minimize the effect of temporary weather extremes, it is recommended that the typical meteorological year is described by taking a 10-year average of the occurrence of the different types of weather conditions. To determine the long-term equivalent sound level, measurements of meteorological data should comply with ISO 1996-2:1987 (Ref. 5)

Toolkit 18 provides suggested default values for meteorological conditions. However, **WG-AEN strongly recommends** that every effort should be made to obtain locally representative meteorological data.

2.08 Reviewing strategic noise maps

Issue

Article 7 (5) of the END requires that noise maps shall be reviewed, and revised if necessary, at least every five years after the date of their preparation.

Discussion

The END does not define when a review and possible revision of strategic noise maps is necessary other than at least every five years. However, if a

[2] 'Representative' has been used because a nearby site may not be representative in meteorological terms. It must be emphasised that 'representative' is a much more stringent criterion than 'nearby': a measurement site can be 'nearby' without necessarily being representative e.g. meteorological measurements from the top of a hill are not necessarily representative of the conditions in a nearby valley.

major development takes place during this five-year period, some maps or parts thereof (and action plans) may need to be reviewed and revised.

WG-AEN's recommendations

WG-AEN recommends that Member States should develop their own criteria for reviewing and revising strategic noise maps over and above that specifically required by the END (i.e. every five years).

2.09 Special insulation against noise

Issue

In Annex VI (1.5) it is stated that special insulation against the noise in question means 'special insulation of a building against one or more types of environmental noise, combined with such ventilation or air conditioning facilities that high values of insulation against environmental noise can be maintained'.

Discussion

It is not a mandatory requirement of the END to provide the number of persons living in dwellings with special insulation against noise. In Annex VI (1.5) the END states '…where appropriate and where such information is available'. However, there is a need to define what constitutes 'special insulation' as this can have a different meaning in different Member States.

WG-AEN's recommendations

WG-AEN recommends that Member States only identify dwelling units as having special insulation where the facades and/or roofs have been treated specifically to improve the sound insulation to external noise and sound insulated air conditioning or ventilation units have also been installed. All this work should have been undertaken either:

- to satisfy a requirement (relating to the attenuation of external noise) of a planning consent for the construction of the dwelling unit; or
- as part of a special noise insulation programme/scheme which has been undertaken to reduce the impact of external noise in an existing dwelling unit.

It is also recommended that dwelling units specifically designed so that windows to all noise-sensitive rooms do not face onto a nearby noise source, should be counted as having special insulation for the purpose of END reporting.

Source Related Issues

2.10 Road traffic models. Traffic flows and traffic speeds.

Issue

Article 5 (1) of the END states that 'Members States shall apply the noise indicators L_{den} and L_{night}, as referred to in Annex I, for the preparation and revision of strategic noise mapping in accordance with Article 7.'

Discussion

It will generally be impractical for Member States to make traffic flow, composition and speed measurements for all the roads covered by the END. Therefore, it is likely that most Member States will use traffic models as the basis of obtaining a lot of this data for strategic noise mapping purposes (especially for agglomerations). These models often only provide peak hour flow and composition data and journey time speeds[3]. Such data cannot be used directly for the calculation of the L_{den} and L_{night} indicators and, therefore, need to be factored to provide long-term day, evening and night data. There are several possibilities for doing this, for example, by using the traffic data that has been measured to develop, validate or maintain a traffic model. From such measurements it may be possible to produce conversion factors for various categories of roads that can then be used to estimate the day, evening and night-time flow on these roads. Alternatively, such conversion factors could be developed from long-term flow and speed measurement studies specifically undertaken for this purpose.

WG-AEN's recommendations

WG-AEN recommends that special long-term flow, composition and speed measurements are used to obtain real data or to develop conversion factors to obtain long-term day, evening and night data. In the case of agglomerations it may be necessary to derive separate factors for different types of roads. An example to obtain day flow (Q_d), evening flow (Q_e) and night flow (Q_n) from a peak hour flow (Q_{peak}) is provided below.

Road Traffic Flows	Metropolitan / Main Roads	Inter-District Roads
Q_d-Flow for the 12 hour day	$= Q_{peak} * 12$	$= Q_{peak} * 0.7 * 12$
Q_e-Flow for the 4 hour evening	$= Q_{peak} * 0.7 * 4$	$= Q_{peak} * 0.5 * 4$
Q_n-Flow for the 8 hour night	$= Q_{peak} * 0.2 * 8$	$= Q_{peak} * 0.1 * 8$

[3] Road traffic models often provide traffic speeds that are based on journey times. These speeds include the delays experienced at junctions, traffic lights etc. For strategic noise mapping, the average speed on free flowing sections of the road is generally required.

(This is just an example obtained from 'Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques' – France, and may only be applicable to large cities)

Further advice on obtaining traffic flow, composition and speed data for roads is provided in Toolkits 2, 3, and 4 respectively.

See also Appendix 5 - Section on Geometric Aspects. Page 111.

2.11 Major roads with less than 6 million vehicle passages per year on some sections.

Issue

In the first round of noise mapping the END requires that strategic noise maps are produced for all roads with more than 6 million vehicle passages per year. However, no detail is provided on how to deal with situations where the traffic flow on some (often small) sections of these roads falls below 6 million.

Discussion

There appear to be 3 options for dealing with such situations:

*Option 1. Map the entire road, including **all** sections with less than 6 million vehicle passages per year, using the true flow in each section. This option is the most coherent as the road is considered in its entirety, which is useful for the development of action plans and the assessment of such plans. However, it may involve more work than options 2 and 3.*

Option 2. Only map the sections of the road where the flow exceeds 6 million vehicle passages per year using the true flow in each section. This option may involve less work than Option 1 but will mean that a lot of separate noise maps need to be produced, and it will be more difficult to use these for co-ordinated action planning.

*Option 3. Map the sections of the road where the flow exceeds 6 million vehicle passages per year and where there are **small** intervening sections of road with less than 6 million vehicle passages per year also include these sections using the true flow in all sections (see the example below). This option limits the area to be mapped but avoids small discontinuities in the maps.*

The following is an example of the Option 3 approach that is based on current practice in France:

- *for major road sections inside agglomerations the maximum section length to be included that has less than 6million vehicle passages per* *year is 100 metres [4];*

- *for major roads outside agglomerations the maximum section length to be included that has less than 6million vehicle passages per year is 500 metres;*

- *for motorways and other roads of national importance outside agglomerations the maximum section length to be included that has less than 6million vehicle passages per year is 1 kilometre.*

WG-AEN's recommendations

WG-AEN recommends the use of Option 3 but Member States should establish their own criteria for identifying which small sections to include.

See also Appendix 5 - Section on Road Segmentation. Page 117.

2.12 Low flow roads in agglomerations

Issue

Annex IV (3) of the END indicates that noise maps for agglomerations have to place a special emphasis on road traffic. A strict interpretation of the END could means that all roads in agglomerations have to be mapped. However, no advice is provided on how to deal with low flow roads where reliable flow data is unavailable, or indeed on which low flow roads need to be mapped.

Discussion

Traffic flow data is unlikely to be available for every road in an agglomeration, especially for low flow roads, but the END implies that all roads have to be taken into account and mapped, in these areas.

There appear to be three possible solutions to this problem, which have varying degrees of associated complexity, accuracy and expense. They are as follows:

1. Obtain and use accurate traffic flow data from a traffic flow model and/or traffic counts for all roads, including low flow roads. This is the best solution.

2. Assign default flow values for roads with flows that are known to have, or are likely to have, flows that are below a certain figure per day (or per year). This solution takes account all roads, which is in accordance with the END.

[4] *This only applies when mapping major roads outside an agglomeration. When mapping an agglomeration the contribution from all roads needs to be considered.*

3. Only map roads where the flow is above a certain figure. This is the most straightforward solution, but could produce an under-estimation of noise exposure.

WG-AEN's recommendations

WG-AEN recommends that, where accurate flow data for all roads is not available, solution 2 should be adopted. See also Toolkit 2 Tool 2.5 and Toolkit 4 Tool 4.5.

2.13 Speeds on low flow roads in agglomerations

Issue

Annex IV (3) of the END indicates that noise maps for agglomerations have to place a special emphasis on road traffic. A strict interpretation of the END could mean that all roads in agglomerations have to be mapped. However, no advice is provided on how to deal with speed on low flow roads where reliable flow data is unavailable, or indeed on which low flow roads need to be mapped.

Discussion

Accurate traffic speed is unlikely to be available for every road in an agglomeration, especially for the low flow roads but the END implies that all roads have to be taken into account, and therefore mapped, in these areas. The relevance of this issue depends on the approach adopted for dealing with low flow roads. See section 2.12.

WG-AEN's recommendations

WG-AEN recommends that Toolkit 3 Tool 3.5 is used when speeds on low flow roads in agglomerations are not available[5].

2.14 Geographical errors in road alignment.

Issue

Traffic flow, composition and speed data produced by traffic modelling is often assigned or attributed to sections of road between nodes in a digital road network model that is relatively inaccurate in geographical terms and is unsuitable for the purpose of strategic noise mapping.

[5] When speeds are low the limitations of the calculation method may need to be considered. For example the recommended interim method for road traffic noise NMPB-XP S 31-133 (Ref. 3) only contains the emission values for speeds of more than 20 km per hour. For lower speeds 20 km per hour should still be used.

Discussion

The problem is highlighted in Figure 1. below. A geographically accurate digital road network model is shown in brown. The digital road traffic network model, which has traffic data assigned / attributed to it, is shown in green and is geographically inaccurate.

There are two options for dealing with this problem:

Option 1. Improve the geographical accuracy of the inaccurate digital road traffic network model, for example, by using manual or automatic techniques in a GIS.

Option 2. Transfer the attributed/assigned data from the inaccurate digital road traffic network model to the more accurate network model, for example, by using manual or automatic tools in GIS (It should be borne in mind that the more accurate model may still not be accurate enough for strategic noise mapping purposes).

Figure 1. An example of an accurate digital road network model (brown) and an inaccurate road traffic model network model (green).

WG-AEN's recommendations

It is not for WG-AEN to make specific recommendations on the methods for either improving an existing digital road network model or for the transfer of traffic data from a relatively inaccurate road network model to a more accurate model, but most of this can normally be done using routines contained in noise mapping software or by using GIS tools. However, in the case of data transfer to a more accurate model it is inevitable that some of this will have to be done manually and this will be time consuming and will require a high level of expertise.

It is within WG-AEN's remit to address the issue of the final accuracy of the model used for strategic noise mapping. WG-AEN recommends that, if a sufficiently accurate digital road network model is not available, such a network should be generated by improving the geometry of the best model that is available. It is for those carrying out noise mapping to decide what is 'sufficiently accurate' in such circumstances but, as a minimum, WG-AEN recommends that the modelled road (or lane centre lines if these are used - See sections 2.18 and 2.19) should not normally fall outside the edge or perimeter of the road corridor.

2.15 Road Surface Type

Issue

Road surface type is normally a required parameter for calculating the basic noise emission from a road traffic source.

Discussion

Most calculation methods used within the EU use one attribute for the road surface [6], the road surface material. When this is not known, there is a need to make a compromise. Suggested compromises are included in Toolkit 5.

WG-AEN's recommendations

WG-AEN recommends that Toolkit 5 is used where the road surface type is not known.

2.16 Speed Fluctuations at Road Junctions

Issue

Vehicles driven at a constant speed produce a relatively constant noise level. Noise around road junctions, where vehicles are decelerating, braking and then accelerating, may vary considerably.

Discussion

Whilst some road traffic noise calculation methods do not have any means of dealing with traffic situations around road junctions, this is not the case with the END's recommended interim calculation method for road traffic noise (Ref.3). Therefore, it may be necessary to identify the sections of road near to junctions where deceleration and acceleration take place.

WG-AEN's Recommendations

WG-AEN recommends that Toolkit 6 is used where road sections with decelerating and accelerating traffic around road junctions are not known and this information is required.

[6] The UK calculation method CRTN (Ref. 4) has two variables, the road surface material and the texture depth. The accuracy study (Ref. 2) contains a Toolkit for the CRTN texture depth.

2.17 Road Gradient

Issue

Road gradient is normally a required parameter for calculating the basic noise emission from a road traffic source.

Discussion

Most calculation methods used within the EU require information on road gradient. For noise mapping, road gradient information is normally derived by draping the road segments over the underlying ground model to derive road height and from that derive road gradient information. In many circumstances, a full and detailed ground model may not be available, particularly where there are cuttings or embankments. In some cases, no suitable ground model data may be available at all.

WG-AEN Recommendations

WG-AEN recommends that Toolkit 7 is used where road gradient for each road segment is not known.

2.18 Determination of the number of road lanes.

Issue

Road corridors have different numbers of road lanes varying from a single lane (one-way streets) to multi-lanes (for example on motorways and ring roads). Often road traffic noise may need to be calculated with individual lanes modelled as separate noise sources and in such cases it will be necessary to determine the number of individual lanes.

Discussion

It is not always necessary to know the number of road lanes in a road corridor for strategic noise mapping. For example where; the width of the road corridor is quite small; sensitive receptors are far away from the road; the immediate surroundings of the road will not have a strong influence on noise propagation; the traffic flows are homogeneously distributed across the road lanes.

However, even for strategic noise mapping purposes, it is often necessary to establish the number of lanes and assign traffic data to each (the assignment of traffic data is addressed in section 2.19) to achieve an acceptable level of accuracy.

WG-AEN's recommendations

Where the number of road lanes in a road corridor is not known and it is judged that this data is required (see above discussion), WG-AEN recommends that site visits should be made to determine the number of lanes. By doing so it should also be possible to establish if there are lanes which are used just for parking and should not be considered as noise sources and if there are 'special' lanes such as bus lanes and lanes restricted to light vehicles which may need to be taken into account. If it is not possible to make a site visit it should be possible to determine the number of lanes from maps, aerial photography or a knowledge of the road corridor or carriageway widths by assuming a nominal lane width, for example 3.5 metres.

2.19 Assignment of flows and speeds to different lanes of multi-lane roads

Issue

To assess the noise from multi-lane road corridors where roads are two-way it is often necessary to at least assign different flows and speeds to each direction. It is often also necessary or desirable to assign different flows and speeds to each lane of such road corridors (see discussion in section 2.18) if the calculation method requires or allows for this to be done.

Discussion

Traffic flows and speeds are frequently not readily available for every lane of multi-lane road corridors and occasionally may not even be available for each direction.

Alternative ways of assigning flows and speeds in such circumstances are discussed below:

Assignment by lane.

Where data is available for each lane of a multi-lane corridor and this shows that there is a significant difference between the traffic data for each lane it may be appropriate to assign different data to each lane. It may be important to do this where reception points are close to the road or when the immediate surroundings of the road may have a strong influence on noise propagation (for example, where a road is in a cutting or on an embankment).

Assignment by direction.

This is normally necessary and particularly so when it is known that traffic data for the different directions are significantly different or when the road gradient may significantly affect the noise emission (as determined by the model being used but typically when the gradient is greater than 3%).

Assignment by road.

In this case a combined two-way flow is assigned to a multi-lane road (normally to the centre line of the road corridor). This is generally only *acceptable for strategic assessment when the road gradient is not important (as determined by the model being used but typically when the gradient is less than 3%).*

WG-AEN's recommendations

WG-AEN recommends that for strategic noise mapping either data for each lane or for each direction of a multi-lane road should be used when available. However, where such data is unavailable it may be appropriate to divide the total flow equally across each lane of a multi-lane road.

2.20 Calculation of railway noise

Issue

The END recommends that Member States who have no national computation method for railway noise, or Member States who wish to change their computation method, should apply the Netherlands national method published in 'Reken- en Meetvoorschrift Railverkeerslawaai '96, Ministerie Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 20 November 1996' (RMVR 1996) (Ref.6).

Discussion 1

RMVR 1996 was developed with particular reference to typical trains in the Netherlands, with the rolling noise element based on levels produced on typical Netherlands track without obvious defects on its running surface. It contains a database having ten noise emission categories from trains on the Dutch network. For other Member States to use the recommended interim method, they need to follow set procedures to categorise their trains in this database. These procedures have been produced but they were not included, or referenced in RMVR 1996. Consequently, they are not part of the recommended interim method. The first formal reference to these procedures was not made until the publication of RMVR 2004 (Ref.7).

WG-AEN's Recommendations 1

WG-AEN recommends that Member States who choose to use RMVR 1996 to calculate railway noise for the purposes of complying with the END, use the concepts of the procedures that are referenced in RMVR 2004, modified as outlined below, to place their trains either into the ten noise emission categories provided in RMVR 1996 or, where their trains do not fit into these categories, into additional categories.

Discussion 2

For a Member State other than the Netherlands to use RMVR 1996 it will be necessary for it to consider whether its trains and track differ in acoustic terms from the situation in the Netherlands, and if so, decide whether it wishes to account for this.

The following discussion focuses on rolling noise but it is not intended to prescribe exactly how it should be accounted for. It provides a number of options by which relevant reference source terms for different trains can be obtained for input to RMVR models. These options are presented in order of increasing complexity, and generally also increasing accuracy and, therefore, it would be advisable to select the method that provides the greatest accuracy within practical constraints.

Options 1 - 3 are based on the concepts of Method (Procedure) A referred to in RMVR 2004, where rolling noise is represented by a single noise level containing both the vehicle and track contributions to the noise. Options 4-9 follow the concepts of Method (Procedure) B of that document, where the track and vehicle contributions are identified separately and allocated to source heights of 0.0 metres and 0.5 metres relative to railhead respectively. All the Options derive the total rolling noise level as a starting point but, where separation of this total level into track and vehicle contributions is required (as in Options 4-9), this is achieved by subtracting a calculated vehicle or track contribution from the total.

Option 1	*Use the physical characteristics of the train (e.g. cast iron block brakes or disc brakes) to allocate it to an appropriate Dutch train category (1-10) from RMVR.*

(This option has potentially the lowest level of accuracy, because it is dependent upon a judgement of the similarity between the trains in question with a defined Dutch category. It makes no correction for roughness and therefore implies that wheel and rail roughness levels are similar to those found in the Netherlands).

Option 2	*Option 1 with a correction for the assumed typical roughness of the Member State's track, as in Measurement Method (Procedure A) of RMVR 2004. (This option assumes that wheel roughness for block or disc brakes in the Member State will be similar to that in the Netherlands. Separate correction factors for track roughness will be required for each brake type).*
Option 3	*Measurement of train pass-by noise, with acceptance of the track as being typical of that found in the Member State by also measuring the pass-by noise of a disc braked vehicle of known acoustic characteristics (Ref.8). This method can also be used to determine the aerodynamic content of noise for trains at high speed.*
Option 4	*Option 3 but with a nominal apportionment of sound energy emission at two heights (0.0 metres, 0.5 metres above rail head) to represent track and vehicle contribution, using default apportionment values (Ref.9).*

Option 5	*Option 3 but with nominal default values for combined effective wheel and rail roughness **(NB "effective" because this includes "contact filter" effects at the wheel / rail interface)** and for transfer functions between combined roughness and, separately, vehicle and track sound energy contribution (Ref.10).*
Option 6	*Option 3 but with combined effective roughness determined by indirect measurement techniques (e.g. PBA (Pass By Analysis software)), and with nominal default transfer functions between combined roughness and, separately, vehicle and track sound energy contribution (Ref.10).*
Option 7	*Option 3 but with wheel and/or rail roughness measured directly (using defaults where one of these is not available) and with contact filter effects accounted for. Also, with nominal default transfer functions between combined effective roughness and, separately, vehicle and track sound energy contribution (Ref.10).*
Option 8	*Option 3 and the use of one, or more of, the techniques PBA / VTN (Vibro-acoustic Track Noise software) / MISO (Multiple in Single Out software) (Ref.10) or similar techniques to determine combined effective roughness and the transfer function between this roughness and, separately, vehicle and track sound energy contribution.*
Option 9	*Option 3 with direct measurement of the roughness of the wheel and/or rail and the use of one or more of the techniques such as PBA to determine combined effective roughness (where it has only been possible to measure directly wheel or rail roughness but not both). Subsequently to use VTN/MISO (Ref.10) to measure the transfer function between this roughness and, separately, vehicle and track sound energy contribution. (This option, especially where both wheel and rail roughness can be measured directly, is likely to provide the highest precision in determining rolling noise source terms).*

WG-AEN's Recommendations 2

WG-AEN recommends that, for the purposes of strategic noise mapping, Member States opting to use RMVR 1996 should characterise their trains by using one of the first three options outlined in the above discussion. To be consistent with other recommendations made in this Position Paper, Option 3 is preferred. This provides a single noise level characterisation for a Member State train on a Member State track and is likely to be the most accurate of the first three options. Option 2 would be the second preference. If, however, it is felt necessary to obtain emission data for vehicles and track separately one of the options 4 to 9, which are based on Procedure B, will have to be used.

2.21 Rail roughness

Issue

The most significant source of noise from rolling stock is that produced by rail-wheel interaction. The reduction of this noise generation is partly regulated by Directives like 96/48/EC (Ref.11) and 2001/16/EC (Ref.12) concerning the interoperability of rolling stock operating on the trans-European railway system. The Technical Specifications for Interoperability (TSI) for new Rolling Stock set tighter sound emission limits, suitable rules on maintenance and even considers the retrofitting of brake blocks.

Discussion

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. Before using a calculation method for rail traffic noise, it is necessary to check how the method takes into account the rail roughness. If the method takes into account the relevant rail roughness, then ideally this should be identified for each sub-section of track [7].

WG-AEN recommendations

WG-AEN recommends that where data are available on rail roughness this should be used in the calculation of noise maps, if the chosen calculation method permits this. Where no data is available some average national figures should be defined. If they exist, national guidelines on rail roughness standards may be a starting point.

2.22 Trams and the sound power levels of trams and light rail vehicles

Issue

There are a wide variety of light rail transport (LRT) systems in use in urban areas across Europe but often it is difficult to decide what is an LRT system and what is a "regular train" system.

The main noise from LRT systems is rolling noise, which can be calculated using standard methods. Squeal noise, which can be a serious problem with LRT systems, is more difficult to address.

[7] Local rail grinding can be very effective in reducing rolling noise if wheels are smooth and rails highly corrugated. However, the implementation of practical grinding strategies on track with a typical roughness distribution found across a rail network will provide significantly less global benefit.

Discussion

With LRT systems a major distinction has to be made between situations where light rail vehicles (LRVs) run on segregated track and where they run on shared alignments with normal road vehicles. In some cases the same LRV may be found running as subway/underground train in the centre of a city (on ballasted or slab track), as a tram just outside the centre (in the road surface) and as a light rail/ train in out-lying districts (back on ballast).

Two issues need consideration.

1. *How to calculate the noise emission for LRT systems*
2. *How to noise map LRT systems*

1. Calculation of noise emission
Sound power levels for LRTs are needed for strategic noise mapping. As there are many different types of LRV in use across Europe this data may not always be available. For LRVs on ballasted track, standard procedures for calculating the data apply and some noise emission data are available. For trams on road surfaces the availability of such data is less common and additional data may have to be gathered through measurement.

Squeal noise remains common problem, particularly for trams and LRT systems, although a combination of solutions has been used successfully on some systems. Currently, it is not easy to predict the effectiveness of such solutions, and therefore success in controlling squeal at the design stage is not always guaranteed. Tight curves cause the vast majority of squeal problems, but in many cities, and particularly in historic city centres, these cannot always be avoided and best practice designs need to be implemented.

2. Noise Mapping
LRV's running on segregated track can be mapped as for regular railway noise. LRV's running on track in the street could either be mapped in with road traffic or as a separate railway source. If they are mapped in with road traffic the results may need to be separated for the purposes of developing action plans. If mapped as a separate source a complex double exposure situation may result.

WG-AEN's Recommendations

WG-AEN recommends that LRT systems in urban areas are mapped as 'regular trains' where they run on segregated track. For tram-type vehicles running along roads with road traffic (often with rails embedded in the road surface) the choice, which is left to Member States, is either to map them together with the road traffic, or separately. In either case the resulting noise exposure should be kept separated for the purpose of action planning. Information on noise levels produced by trams and LRTs will often be available from the operators and if not already in terms of required sound power levels can normally be easily converted. However, if such information is not available WG-AEN recommends that Toolkit 8 should be used. Sound propagation calculation procedures should be as for rail traffic for LRT's in ballast or as for road traffic for trams on road surfaces.

2.23 Train (or tram) speed

Issue

The speed of a train/tram is an important parameter when calculating the noise emission from railways and tramways.

Discussion

The maximum permitted speed on a rail section may vary considerably along a rail corridor depending on local conditions and may vary from track to track. In addition, not all trains/trams will travel at the permitted maximum speed. Scheduled speeds often have an in-built allowance for catching up on minor delays. The speed of freight trains will normally be lower than passenger trains on the same tracks. It is often difficult to obtain reliable train speed data, particularly for freight trains.

The guidelines in the calculation method that is to be used for strategic noise mapping should be checked to establish if the method requires the speed on the section of track being considered or the average speed over a complete journey.

WG-AEN's recommendation

WG-AEN recommends that Toolkit 9 is used where reliable train or tram speed data is not available.

2.24 Major railways with less than 60,000 train passages per year on some sections.

Issue

In the first round of noise mapping the END requires that all railways with more than 60,000 train passages per year are noise mapped. However, no detail is provided on how to deal with situations where the number of train passages on some (often small) sections of these railways falls below 60,000.

Discussion

The question is what to do when a major railway with generally more than 60,000 train passages per year has some, often small, sections with passages of less than 60,000 passages per year.

There appear to be 3 options for dealing with such situations.

Option1). Map the entire railway, including ***all*** *sections with less than 60,000 per year, using the true number of passages in each section. This option is* *the most coherent as the railway may be considered in its entirety and this is useful for action planning and the assessment of these plans. However, it may involve more work than options 2) and 3).*

Option 2.) Only map the sections of the railway where the flow exceeds 60,000 passages per year using the true number of passages in each section. This option may involve less work than Option 1 but if the lengths of sections identified are very small this will produce a lot of separate noise maps and it will be more difficult to use these for co-ordinated action.

*Option 3). Map the sections of the railway where the flow exceeds 60,000 passages per year and where there are **small** intervening sections of rail with less than 60,000 train passages per year also include these sections using the true number of passages in each section. This option limits the area to be mapped but avoids small discontinuities in the maps. An e*xample of this type of approach in respect of major roads is provided in section 2.11.

WG-AEN's recommendations

WG-AEN recommends the use of Option 3 but Member States should establish their own method for identifying which small sections to include.

2.25 Noise from stopping trains in stations

Issue

Passenger trains that stop at a station can cause considerable noise disturbance when arriving at, standing at and departing from the station. Train noise calculation methods do not always allow for the calculation of such noise. This can result in strategic noise maps which show unrealistically low noise levels near railway stations, particularly those where most passenger trains stop.

Discussion

If the calculation method to be used by a Member State does not allow for the calculation of noise from stopping trains then that Member State could carry out noise measurements on different types of trains both in free running conditions and when stopping in stations to derive typical train speed that, when input into the calculation method, would produce the noise levels similar to those produced by a train of the same type when it stops in a station. Alternatively, a Member State could derive or estimate such a speed to be used for all stopping trains. It seems that an equivalent speed of 40km/h may be appropriate, although this figure has not been substantiated by rigorous research.

WG-AEN recommendations.

WG-AEN recommends that where a Member State wishes to map noise around railway stations and their chosen calculation method does not include a means for calculating noise from trains which stop at stations then an equivalent speed of 40km/h could be assigned to these trains other than at termini. A decision will need to be made about what length of track this equivalent speed is applied to.

2.26 Geographical errors in rail track alignment

Issue

The train flow, composition and speed data held by railway authorities that is required for noise mapping by computation needs to be attributed/assigned to a digital rail network model that is sufficiently accurate for strategic noise mapping purposes

Discussion

Train flow, composition and speed data currently held by railway authorities may not always be attributed to a digital rail network model. Even where it is, the model may need to be improved for the purposes of strategic noise mapping. If the data is not attributed to such a model then a model will need to be created, for example, by manual digitisation. The question is how accurate does a rail network model have to be to make it sufficiently accurate for the purposes of strategic noise mapping?

WG-AEN Recommendations.

WG-AEN recommends that for the purposes of strategic noise mapping the digital rail network should contain the approximate centre line of all tracks of the rail corridor that are in use and none of these centre lines should fall outside the boundary of the rail corridor

2.27 Assignment of train movements to different tracks in a multi-track rail corridor

Issue

Information on the number of tracks in a multi-track rail corridor will generally be required for strategic noise mapping. Fortunately, this information is normally relatively easy to obtain from the railway authorities or operators or from maps, aerial photography or site visits. However, for the assessment of the noise exposure, particularly where dwellings are close to a multi-track rail corridor, it is normally also necessary to distribute trains to specific tracks. Most national computation methods and the recommended interim computation method for railway noise (Ref.6) require or can accommodate such information but it may not always be readily available.

Discussion

In most instances it should be possible for railway authorities to supply the train movement data in such a way that the assignment of train movements to the different tracks is possible.

If the distribution of the trains to the different tracks is not available the trains could either be assigned to the tracks in a statistical manner based on the local situation or could be uniformly distributed across the tracks.

Alternatively, all or most trains could be assigned to the track nearest to the receptors being considered. Normally, this would give the worst-case scenario.

WG-AEN's recommendations

WG-AEN recommends that if track assignment data are available they should be used for strategic noise mapping.

If data are not available, WG-AEN recommends that the number of trains be assigned to the different tracks based on local knowledge or, as a last resort, in a uniform manner i.e. the same number of trains on each track.

2.28 Helicopter noise

Issue

Although helicopter noise is not specifically mentioned in the END it can make a very significant contribution to the noise environment in areas where helicopters operate regularly, and particularly in agglomerations where there are heliports. Therefore, noise from these sources may require some consideration in agglomerations when carrying out strategic noise mapping.

***Discussion**.*

Helicopter noise can be dominated by "ground noise" that is noise generated by helicopters during terminal operations on or over the ground surface.

These operations involve hovering and taxiing manoeuvres as well as idling with rotors running, which, by comparison with over flight noise events, are very lengthy with durations measured in minutes rather than seconds. As ground operation can cause more noise disturbance than that caused in flight, the contribution of this to noise exposure (in L_{den}/L_{night}*) can be significant.*

The difficulty is that noise from a hovering helicopter varies with its height above the ground, with it's loading, with azimuth angle and with the prevailing wind conditions (small wind changes can have large effects upon rotor flow patterns that influence noise). Furthermore, ground-to-ground sound propagation depends upon wind speed and direction, air temperature and humidity (and how these vary above the ground), local topography and the *nature of the ground surface, and the presence of buildings and other similar obstacles.*

As a consequence of this, progress in the development of reliable noise modelling methodology is not as advanced as in the case of fixed wing aircraft. In fact the recommended interim method for calculating aircraft noise does not provide a means for including helicopter noise in the assessment of noise around airports.

However, a Helicopter Noise Model called HNM version 2.2 exists (Ref.13) and is available in a US Federal Aviation Authority (FAA) computer programme. This may be of help in the assessment of helicopter noise in the vicinity of heliports. It is based on the aircraft equivalent Integrated Noise Model (INM) (Ref.14) but differs from INM in its ability to accommodate the greater complexity of helicopter flight activities.

In addition, NASA, in cooperation with the US Department of Defence, has developed the Rotorcraft Noise Model (RNM) (Ref.15).

RNM version 1.0 is designed to model details of tiltrotor operations not possible to model with HNM. HNM and RNM represent the current state-of-the-art for heliport noise modelling.

WG-AEN's recommendations

At present, WG-AEN does not believe that it is possible to recommend any simple procedure for calculating helicopter noise for inclusion in strategic noise mapping. However, those wishing to include helicopter noise in their mapping should consider the use of HNM or local noise measurements.

2.29 Noise from aircraft activities other than aircraft movements and noise from other sources at airports[8]

Issue

The END includes requirements for noise mapping of all airports within agglomerations and major airports outside agglomerations. It also requires noise mapping of sites of industrial activity within agglomerations and this is somewhat at the discretion of Member States, as the END does not define an industrial activity (see Article 3 (a) of the END).

This raises two questions. What noise sources should be mapped when considering an airport within an agglomeration and what sources should be mapped when considering an airport outside an agglomeration?

[8] For the purposes of this Position Paper, aircraft movement noise concerns noise from aircraft take off, flight and landing.

Discussion 1

Regarding airports within an agglomeration, it is clear from the END that roads and railways have to be mapped [at least when their noise contribution is greater than 55 L_{den} or 50 L_{night}] and that these sources of noise should be mapped separately from each other and separately from aircraft movement noise (i.e. noise from take-off, flight, and landing), which also has to be mapped. The real question is whether noise from activities at these airports that is not directly associated with aircraft movements or from roads and railways should be considered as industrial sources and mapped accordingly. These noise sources could include: aircraft taxiing; auxiliary and ground power units; aircraft engine testing; plant and vehicles operated within the airport security perimeter; car parks. The decision on what to include rests with Member States.

WG-AEN's recommendations 1

WG-AEN recommends that noise from all activities at any airport within an agglomeration should be noise mapped, particularly when their noise contribution is greater than 55 Lden or 50 Lnight. Noise that is not associated with aircraft movements and is not mapped as road or rail traffic noise should be considered as industrial noise and mapped accordingly so that the full impact of all the noise sources at these airports can be assessed.

Discussion 2

Regarding major airports not within an agglomeration it is clear from the END that, apart from aircraft movement noise (i.e. noise from take-off, flight and landing), only ***major*** *roads and* ***major*** *railways have to be mapped and that these should be mapped separately from each other and separately from aircraft movement noise. There is no clear requirement on Member States to consider mapping noise from other activities at these airports that are not directly associated with aircraft movements or major roads and railways.*

WG-AEN's recommendations 2

At least aircraft movement noise and noise from major roads and railways must be mapped at all major airports outside agglomerations. However, WG-AEN recommends that Member States consider the possibility of also mapping noise from other activities (for example: aircraft taxiing; auxiliary and ground power units; aircraft engine testing; plant and vehicles operated within the airport security perimeter; car parks), particularly when their noise contribution is greater than 55 Lden or 50 Lnight, so that the full impact of these airports can be assessed.

2.30 Sound power levels of industrial sources

Issue

Sound power levels of industrial sources are required in order to calculate noise levels and exposure from industrial activities.

Discussion

Sound power levels of industrial sources often vary with time e.g. from hour to hour, day to day and seasonally. In addition, the sound power levels may not be known.

WG-AEN's recommendations

WG-AEN recommends that Toolkit 10 is used, when the periodic variation in sound power level of an industrial source is not known and/or the sound power levels themselves are not known.

Propagation Related Issues

2.31 Ground surface elevation

Issue

Ground elevation contours with a vertical resolution of 5 or 10 metres are often used for strategic noise mapping. However, this resolution is not necessarily sufficient to determine accurate sound propagation close to some noise sources e.g. roads or railways in cuttings or on embankments. In such circumstances the ground elevation close to the source may have to be given to an accuracy of 1 metre.

Discussion

The most straightforward method of obtaining better ground height information is to take ground heights from a digital terrain model in order to produce an accurate acoustic model near to sources that are elevated or in cutting. Other methods that may be employed include the use of Global Positioning Systems, lidar, photogrammetry or manual surveying and visual inspection.

WG-AEN's recommendations

WG-AEN recommends that for strategic noise mapping for the END use should be made of the most accurate data available or obtainable and Toolkit 11. For further advice, specifically in relation to cuttings and embankments, see Toolkit 12.

See also Appendix 5 - Section on Source Height. Page 111. Section on Ground Elevation. Page 112. Section on Ground Terrain Modelling. Page 118.

2.32 Ground surface type

Issue

Most noise calculation methods that are likely to be used in the first round of strategic noise mapping for the END will contain some means of including ground attenuation in the assessment of noise propagation. However, there is no guidance on the relative importance of adopting the correct ground type or guidance on how to deal with a partial knowledge or total lack of knowledge of ground type information. There is also a lack of guidance on what minimum area of particular ground types should be taken into consideration for strategic noise mapping for the first round of the END.

Discussion

In many noise mapping exercises carried out to date hard ground conditions have been assumed across the entire noise model so that the results are based on 'worst case' noise propagation scenarios. However, ground type is an important factor and can have a significant affect on noise levels. Generally more effort needs to be made to represent the ground type more correctly in noise mapping calculations.
Where there is a lack of comprehensive data on ground type it would seem sensible to use default values e.g. hard ground for urban areas and soft ground for areas in the open country. It would also seem sensible to ignore small areas of land that have different characteristics to the larger surrounding areas.

WG-AEN's recommendation

WG-AEN recommends that Toolkit 13 is used for the determination of ground surface type. With regard to small areas of land with differing ground surface characteristics to larger surrounding or adjacent areas, it is recommended that it would be appropriate to ignore these areas when they are less than 250 m^2. It may also be appropriate to ignore long, narrow areas of land, for example, roadside verges in agglomerations, where the typical width is less than 3 metres, or narrow roads in open country.

See also Appendix 5 – Section on Ground Surface Type Page 112, section on Modelling of Acoustic Ground Type, Page 119 and section on Ground Terrain Modelling Page 118.

2.33 Barriers

Issue

Purpose built noise barriers are generally located relatively close to the noise source and have a significant effect on the propagation of noise.

Discussion

A small variation in the height or distance of a barrier to a nearby source can produce significant variations in noise levels. Therefore, barrier heights should generally be determined to the nearest 0.5 metres. Likewise, the position should be recorded to an accuracy of 1 metre. However, for strategic noise mapping, these requirements may not be achievable.

WG-AEN's recommendations

WG-AEN strongly recommends that every effort should be made to obtain actual, local data, which is representative of the area being modelled. Where accurate information on the position and height of purpose-built barriers relative to a noise source is not known, use should be made of Toolkit 14.

A further recommendation of WG-AEN is that for the purposes of strategic noise mapping for the END, which has to be undertaken at a height of 4 metres, it is generally acceptable to ignore non-purpose built barriers such as small garden walls and fences and earth mounds.

2.34 Building heights

Issue

The height of buildings can have a significant effect on the propagation of noise particularly in built up areas.

Discussion

Accurate building height data needs to be obtained wherever possible but the acquisition of such data can be expensive and the levels of accuracy of the various methods of obtaining it vary considerably. However, information on the number of storeys (floors) of a building is normally available or can be obtained at relatively low cost.

WG-AEN's recommendations

WG-AEN recommends that Toolkit 15 is used where accurate and reliable building height data is not available or obtainable.

See also Appendix 5 – Section on Building Heights, Page 112 and section on Building Height Information Page 119.

2.35 Simplification of building outlines

Issue

The modelling of building shapes constitutes an important part of computer-aided sound propagation computation where they are represented as vector structures, which can obstruct, reflect and absorb sound in the sound propagation path.

Discussion

Computation of the affects of building structures and barriers on sound propagation involves complex calculations. This is further complicated by the fact that when these objects are obtained in a digital format the level of building outline detail is often extremely high. So to speed up the computation process it will normally be necessary to optimise the 'Digital Buildings Model'. Effectively, this means that the buildings structures dataset (the building outlines) must be simplified. However, too much simplification will reduce accuracy. In particular, too much simplification can significantly alter building outlines.

WG-AEN's recommendations

WG-AEN recommends that for the purposes of strategic noise mapping for the END, the tools that are commonly available in GIS (and available is some noise mapping software) that facilitate the simplification of building shapes, and the shape of other objects that can influence sound propagation e.g. noise barriers, are used to simplify their outlines. For example, such functions could be used to remove any elements of a building envelope that are less than 1 metre in length. It is recommended that prior to the selection of the final model test areas are used to assess the impact of the available simplification options upon the final calculated noise levels.

2.36 Merging of heights on individual buildings and buildings of a similar height

Issue

Simplification of building heights is often carried out to reduce computation time when carrying out noise mapping.

Discussion

It is sometimes necessary to assign one height to a single building, which has several different heights, in order to reduce the complexity of the noise model and thus computation time. For the same purpose it may also be appropriate to assign the same height to adjacent (connected) buildings that are of similar height [9]. Tools in a GIS can normally be used to automatically carry out both of these tasks.

[9] This approach can remove partitions between buildings. In the case of residential buildings these partitions will need to be re-instated in the model before assigning people to buildings for the purposes of determining noise exposure.

WG-AEN's recommendations

WG-AEN recommends that, for the purposes of strategic noise mapping, a single building with varying heights can be assigned the height of the majority of the building where the difference in these heights is no more than a specific figure, for example 2 metres. Also, for all adjacent (connected) buildings, where the buildings have a similar height, for example within 2 metres, they can all be assigned the lower of these heights. It is recommended that test areas are used to assess the impact upon the final calculated noise levels of merging sets of buildings together prior to approval for the final model.

2.37 Tunnel openings in the model

Issue.

Noise from road traffic, trains and light rail transit (LRT) systems inside tunnels is often audible outside tunnel openings.

Discussion

Tunnel openings could be regarded as a noise source. However, in virtually all cases the noise at nearby receptors will be dominated by noise generated outside the tunnel.

WG-AEN's Recommendations

It is recommended that for the purposes of strategic noise mapping no account need be taken of noise from within a tunnel and that a tunnel opening should be modelled as a reflective surface.

2.38 Sound absorption of building facades and barriers

Issue

Sound is propagated both directly and by reflection from buildings and other obstacles. The contribution from reflections depends on the location and size of the reflecting surface and the reflection coefficient of that surface.

Discussion

Most mapping software is capable of dealing with first order or second order reflections. However, in many instances the absorption coefficients of the reflecting surfaces will not be known.

WG-AEN recommendations

WG-AEN recommends that Toolkit 16 is used if no specific data on sound absorption exists for a reflecting surface and the chosen computation method permits the input of such data.

2.39 Consideration of Meteorological Impacts and Favourable Sound Propagation Conditions

Issue

Certain meteorological conditions such as wind direction, wind speed, wind turbulence, humidity, temperature, temperature inversion and cloud cover, can have significant effects on sound propagation. The effect of these conditions within agglomerations is generally less than outside these urban areas. Also, ground surface effects and barrier attenuation are influenced by some meteorological conditions and the location of the source/receiver can determine the effect that meteorological conditions have e.g. if the source/receiver is located in an open, exposed or elevated position. Meteorological conditions may vary considerably throughout the day. For instance wind speeds are generally higher during the day and temperature inversions are more frequent at night. In general the attenuation of noise varies with the frequency of the sound, and the humidity and temperature in a complex manner.

Discussion

The influence of meteorological conditions on sound propagation is dependent on a number of factors. Some of these influences can lead to the absorption of sound and the deflection of sound away from the receiver or conversely the sound path to the receiver can be enhanced through favourable sound propagation conditions. As weather conditions may vary considerably in time, these conditions may heavily influence day-to-day or hour-to-hour sound levels. The degree to which the year average sound levels are influenced depends to a large extent on the prevalence of these conditions. Propagation over snow is therefore an issue in Finland, but may be ignored in Sicily. The END is mainly interested in inputs based on yearly averages, with most models handling annualised average daily/hourly information.

Some noise calculation methods may not require the input of meteorological data. However, the harmonised method, designed to be used by all Member States in the future, will require this information and, therefore, it is appropriate to commence monitoring for this data now. Within the context of the END, where assessment has to be made in relation to day, evening and night periods, it will be necessary to obtain meteorological data for these periods separately. Some meteorological conditions vary considerably between day and night-time, i.e. higher wind speeds during the day and temperature inversions at night. An average 24 hr value may not be appropriate in these circumstances.

Within a dense urban setting, due to the closeness of buildings and the varying widths of roads etc. meteorological conditions, when compared to other variables, do not have a dominant effect on sound pressure levels. In most situations they can be ignored. The exceptions are for large open areas, aviation noise and elevated sources/receivers. Most of the weather conditions *that impact on sound propagation can be combined into various categories of 'stability classes', which can be allowed for in some calculation methods. Set out below is a short summary of the meteorological conditions that can influence sound propagation. However, it should be borne in mind that at present it is only possible to model favourable (i.e. favourable to sound propagation from the sound source to the receiver) and neutral conditions. Unfavourable conditions are modelled as neutral (Ref.5).*

Propagation Related Issues

- ***Humidity and Temperature***

Atmospheric absorption is influenced by sound frequency, relative humidity, temperature and atmospheric pressure. Atmospheric absorption increases linearly with distance and becomes more important the greater the distance the sound propagates. Very little attenuation is found for low values of relative humidity or temperature. Monthly and diurnal variations in relative humidity and temperature introduce large variations in atmospheric absorption. Usually, relative humidity reaches its maximum soon after sunrise and its minimum in the afternoon, when temperature is highest. The daily variations are greatest during the summer. Average values for the different humidity and temperature conditions are sometimes used in the predictions, but two different condition distributions can have the same average, causing possible errors. Use of separate long-term averages for different periods of a 24-hour period will be necessary i.e. for day/evening/night.

- ***Wind Velocity/Wind Direction***

The direction and speed in which sound waves travel can be altered by weather conditions, which may result in varying noise levels at the same location at different times. Windy conditions generally cause sound waves to bend in the direction of the wind current. Downwind conditions provide for favourable sound propagation with sound levels tending to be significantly higher than under transverse wind or upwind conditions. For this reason, it is important that the meteorological data is representative for long-term average situations. When deriving the average wind direction conditions, average statistics should be given individually for each wind direction. The use of separate long-term averages for different periods of a 24-hour period will be necessary i.e. day/evening/night.

- ***Turbulence***

Turbulence can have a twofold effect on sound propagation. Firstly, temperature fluctuations lead to fluctuations in the velocity of sound. Secondly, turbulent speed fluctuations produce additional random distortions of the sound wave front. Turbulence scatters sound into sound shadow zones and causes fluctuations of the phase and the amplitude of the sound waves, thus destroying the interference between different sound waves reaching the receiver. This gives higher sound levels than expected for frequencies where the ground is hard – fully reflective. The effect of turbulence can be disregarded for low frequencies and distances up to a few hundred metres in free field conditions.

- ***Inversions***

Temperature inversions provide favourable conditions for the propagation of sound and are perhaps the most significant meteorological factor in the level of sound propagated over open ground and over moderate to large distances. Inversions, where temperature increases rather than decreases with height have the same effect on sound as does 'flat cloud cover'. For example, cloud cover tends to bend sound waves downward towards the ground.

WG-AEN's Recommendations

WG-AEN recommends that Toolkit 17 is used where a noise calculation procedure requires input on the occurrence of favourable sound propagation conditions e.g. temperature inversions, downwind conditions.

It is also recommended that Toolkit 18 is used where a noise calculation procedure requires data on humidity and temperature.

However, **WG-AEN strongly recommends that every effort should be made to obtain actual, local data, which is representative of the area being modelled.** It is also suggested that datasets be developed for the annualised average periods of day/evening/night.

Receiver Related Issues

2.40 Calculation height

Issue

In Annexes I and IV of the END the calculation (assessment) height for strategic noise mapping is specified as 4 metres above the ground. Additional assessment heights may also be used where appropriate.

Discussion

In some situations the assessment height of 4 metres for strategic noise mapping will lead to significant inaccuracy in the assessment of noise exposure. For example, where high-rise residential buildings are exposed to nearby elevated sources, there is likely to be an underestimation of exposure, or where single story residential developments (common in Nordic countries) are close to ground transport sources there is likely to be an over estimation of exposure, particularly as the noise reducing effect of any noise barriers or ground attenuation will be underestimated.

WG-AEN recommendations

WG-AEN recommends that in order to carry out noise mapping for national purposes it may be necessary to undertake additional mapping in selected areas using different assessment heights. This may also be necessary for the development of action plans.

2.41 Most exposed façade

Issue

Annex I (1) of the END indicates that when computation methods are used for the purpose of strategic noise mapping in relation to noise exposure in and near buildings, the assessment points must be at the most exposed façade and that for this purpose, the most exposed façade will be the external wall facing onto and nearest to the specific noise source.

Discussion

*The above text defines the most exposed façade in terms of geometry, not in terms of noise level. If this is taken literally in some instances the most exposed façade will **not** be the façade exposed to the highest noise level from a specific category of source. For example, where road traffic noise from more than one road affects a building.*

WG-AEN's recommendations

The most exposed façade should be taken to be the façade exposed to the highest noise level from the specific category of noise source under consideration (e.g. road traffic).

2.42 Quiet façade

Issue

According to Annex VI (1.5), (1.6) of the END, a façade is 'quiet' if its value of L_{den} is more than 20 dB lower than at the façade having the highest L_{den} level, for the same dwelling unit.

Discussion

According to the above a quiet façade could be exposed to relatively high levels of noise. For example, a façade exposed to an L_{den} of 60dB would be considered quiet if the noise level on the most exposed façade of the same dwelling unit was an L_{den} of 81dB. Therefore, it would seem sensible to identify an upper noise limit for a quiet façade.

WG-AEN's recommendations

It is recommended that to be 'quiet', a façade should not be exposed to an L_{den} of 55 dB or more.

2.43 Assessment point (grid spacing, contour mapping and reflections).

Issue

An assessment point is a physical location at which noise levels need to be calculated or measured for the purpose of producing data to comply with the requirements of the END.

Discussion

Some of the terms in the END require careful consideration to ensure consistency in the calculation of noise levels in various situations:
In Annex I (1) of the END it is stated that assessment points have to be located '<u>at the most exposed façade</u>' and that for the purposes of determining noise levels (at the assessment points) in terms of L_{den} and L_{night} only the incident sound is considered. It is not clear precisely what '<u>at</u>' means. In Annex VI (1.5) of the END, the term '<u>on the most exposed façade'</u> is used.

A different description is given in Annex VI (1.5), (2.5) where the concept of 'a quiet façade' is outlined [10]. Such a façade of a dwelling is one where the L_{den} (or L_{night}), assessed '<u>two metres in front of the façade'</u>, for the noise from a specific noise source, is 20 dB lower than the L_{den} (or L_{night}) '<u>on the façade</u>' of the dwelling having the highest value of L_{den} (or L_{night}).

Finally, a further complication is introduced in that noise levels at grid points also have to be assessed in order to produce some of the data required by the END (e.g. for producing noise contours – see Annex VI (2.7) of the END).

From a literal interpretation of the sections described above, it appears that 3 sets of noise level calculations might have to be carried out in terms of both L_{den} and L_{night} to satisfy the requirements of the END. In summary these are:

- *Set 1. Calculation of noise levels at or on assessment points at building façades, which do not include reflections from the façade in question, in order to determine the levels on the most exposed façade;*

- *Set 2. Calculation of noise levels at grid points that are not linked to facades and which, therefore, could include all reflections* (within the limitations of available computing power and time) *or none at all. These grid-based levels may then be used to produce the noise contour maps that need to be provided to the EC (see Annex VI (2.7) of the END). Such maps or other types of map developed from the contour maps (e.g. conflict maps) may also be used by Member States to present information to the public and decision makers domestically; and*

[10] *It should be noted that the provision of data to the EC on the number of people living in dwellings with a quiet façade is not a mandatory requirement of the END.*

- *Set 3. Calculation of noise levels at assessment points 2 metres from building façades in order to identify the existence of a quiet façade. It is not clear from the END whether such calculations should include a reflection from the façade in question.*

WG-AEN's recommendations

In order to provide pragmatic guidance, and recognising that a range of different software packages, with differing calculation options, will be used by Member States to calculate the required noise values, WG-AEN suggests the following options.

WG-AEN recommends that where possible, **Member States should carry out two sets of calculations.**

(i) For assigning noise levels to buildings

The first set, for assigning noise levels to buildings (and thus people e.g. in practice, at 0.1 metres in front of the facade) should, where the software permits, be calculations of noise levels at the facades of the buildings. Such calculations must exclude reflections from the facade in question, in compliance with the requirements of the END that such levels shall be incident ("free field") noise levels. It is recommended that at least first order reflections from other facades or objects should be included. It is suggested that a spacing of 3 metres between calculation points around the facade is likely to be appropriate.

If the software does not enable automatic generation of such calculation points (e.g. for strategic mapping covering large areas with many buildings), then grid point noise levels, as described below, should be utilised to obtain approximate facade levels. In this case, a correction of minus 3dB should be applied to any grid-based levels that are attributed to buildings and subsequently to the residents of these buildings for determining estimates of noise exposure. Although this 3dB adjustment is a compromise, and may cause some inaccuracies, WG-AEN believes that such an approach is justified in the first round of END strategic noise mapping as the inaccuracies that will result from data deficiencies are likely to be a more significant source of error. The correction factor of 3 dB is chosen to be consistent with the advice in Annex I of the END concerning situations where noise levels at buildings are determined by measurement.

(ii) For noise contour mapping

The second set of calculations, for noise contour mapping and the determination of areas affected by particular bands of noise, require grid-based calculations. These calculations should include at least all first order reflections. Generally, the grid spacing should be no more than 10 metres in agglomerations. A wider spacing in open areas outside agglomerations may give acceptable accuracy although grid spacing should not normally exceed 30 metres. For aircraft noise contours (because these generally change less rapidly and in general are only significantly affected by major topographical features, such as mountains), grid spacing up to 100 metres may be acceptable.

In some locations, especially in urban areas, it may be desirable to use a grid spacing of less than 10 metres. In particular, this need may arise where buildings face each other across narrow roads. Here, depending on software options, either a finer grid (down to perhaps 2 metres in some cases), or software-generated variable grid spacing, should be used. It is recommended that interpolation between 10 metre grid points should **not** be used to overcome this problem, as the interpolation procedures are generally not based on acoustic considerations.

Quiet facades (whose reporting is not mandatory) do not normally face directly onto a nearby major noise source. For this reason, it is suggested that noise levels at the façade [11] (calculated by one of the methods given above) should be sufficiently close to the values at 2 metres from the facade required by the END. This will reduce the number of different values required to be calculated from three to two and also reduce the potential for confusion especially when presenting the results to non-specialists. (See also section 2.42 regarding 'Quiet Facades').

Section 2.44 provides recommendations on how either facade or grid-based noise levels may be assigned to residential buildings and their residents.

2.44 Assignment of noise levels to dwellings

Issue

In order to determine the noise exposure of dwellings, and hence the noise exposure of the residents, noise levels at or close to the dwellings must be calculated.

Discussion

The issue of calculating noise levels at various assessment points is discussed in section 2.43 *where WG-AEN recommends that noise levels calculated either along the facades in question, or at uniform grid points, are used to assign noise levels to residential buildings or dwellings.*

Where information is available on the position of individual dwellings within a building containing more than one dwelling, each dwelling should be treated as if it is a separate building and the appropriate noise levels assigned to that dwelling. Where such information is not available, noise levels around the whole building must first be determined and then an estimate must be made of the highest noise level to be attributed to all dwellings in the building.

[11] The assessment point should be positioned at a small offset, e.g. 0.1 metres, from the facade to ensure that the assessment point is clearly outside the building.

WG-AEN's recommendations

(i) Building consisting of a single dwelling

Where noise levels have been calculated at intervals around the building facades [11] (the preferred option in section 2.43), determine the highest overall noise level and assign this to the dwelling as the value at the 'most exposed facade' in accordance with the recommendation in 2.43. If desired, determine the lowest overall level at a different facade of the building to determine the optional reporting of a 'Quiet Facade', if the '20 dB lower than the most exposed facade' criterion is met.

Where only grid point data are available, firstly subtract 3dB to negate the reflection from the facade in question and then follow a similar procedure linking each surrounding grid point to the facade when the area around the grid point (i.e. a square with sides equal to the grid point spacing centred on the grid point) intersects with a facade. Again, take the highest grid point noise level and assign it to the dwelling. Optionally, also the lowest if wishing to report quiet facades.

(ii) Building containing multiple dwellings where the location of each individual dwelling within the building is known

Where noise levels have been calculated at intervals around the building facades [11] (preferred option in section 2.43), determine the highest overall noise level at any point along any of the exterior facades of each individual dwelling and assign this to the dwelling as the value at the 'most exposed facade' in accordance with the recommendation of section 2.43. If desired, similarly determine the lowest overall level at a different facade of the dwelling to determine the optional reporting of a 'Quiet Facade', if the '20 dB lower than the most exposed facade' criterion is met [12].

Where grid point calculations have been made, the procedure is the same (having subtracted 3 dB to allow for the reflection from the facade in question), linking each surrounding grid point to all of the exterior facades of each individual dwelling when the area around the grid point (i.e. a square with sides equal to the grid point spacing centred on the grid point) intersects with a facade. Again, take the highest overall grid point noise levels at any facade of the dwelling and assign them to the dwelling. If desired, similarly determine the lowest overall level at a different facade of the dwelling to determine the optional reporting of a 'Quiet Facade', if the '20 dB lower than most exposed facade' criterion is met.

[12] This requires that at least one calculation point will fall on each facade of each individual dwelling. In some circumstances this may require adjustment of the spacing between calculation points, although in most cases spacing of 3 metres should be sufficient.

(iii) Building containing multiple dwellings but where the locations of individual dwellings within the building are not known

In this case, the lack of data about the location of individual dwellings within a building will inevitably lead to difficulties in accurately determining the exposures of each dwelling (and hence, the population exposures).

Here the procedure recommended is to follow one of the approaches (i.e. depending on whether façade[11] levels or only grid point calculations are available), given for a single dwelling in (i) above, to calculate the highest overall noise level at any point around the whole building. This highest noise level for the whole building should be attributed to all dwellings in the building as their "most exposed facade" levels. It is recognised that in some circumstances this procedure will lead to an over-estimation of the noise level affecting some of the dwellings within the building, for example, where some dwellings are located so that they do not have a facade on the most exposed façade of the whole building.

However, alternative approaches which attempt to distribute the range of noise levels affecting the facades of the building as a whole to the dwellings within the building (as suggested in Version 1 of the GPG (Ref.1)), may lead to significant under-estimates of dwellings and so population exposure in some situations. Such under-estimation would occur, for example, where all the apartments within the building traverse the width of the building and so have facades exposed to both to the highest overall noise level impacting the building and to lower levels, such as on rear courtyards. In such cases, a proportion of the dwellings would have the courtyard levels assigned to them as their most "exposed facade" levels. Therefore, the procedure recommended here follows the "precautionary principle" [13].

2.45 Assignment of population to dwellings in residential buildings

Issue

Annex VI of the END requires that the Commission is provided with estimates of the number of people living in dwellings exposed to noise levels that fall into specific noise bands.

Discussion

Some Member States may not have detailed data on population distribution. Population distribution, if available, is typically available from several sources, at different levels of detail and for different years, and may not cover all

[13] Because of the potential inaccuracies involved in this method, it is not recommended that the lowest overall noise level at the building is used to attempt to identify the existence of "quiet facades" – such identification is specific to individual dwellings and should only be made where the correct location of a dwelling within a building is known.

demographic groups. It may be necessary to adjust (normalise) data to overall population figures.

It should be borne in mind that, for the purposes of the END, strategic noise maps from which noise exposure data will be derived are to be produced at 4 metres height only and that for many buildings, particularly in built up areas, the resident population will be living at a variety of heights. The issue is discussed further in section 2.40.

WG-AEN's recommendations

If a Member State does not have data that can be used to satisfactorily estimate the number of people living in dwellings in individual residential buildings Toolkits 19 & 20 may be used in combination. These toolkits provide a number of options for producing such estimates.

2.46 Dwelling

Issue

There is no definition of a 'dwelling' in the END although the term is used quite often (Article 3 (q), Annex I (1), Annex III, Annex IV (1) and Annex VI (1.5), (1.6).

Discussion

Unfortunately, a degree of confusion has arisen as some translations of the END refer to dwellings in the context of buildings (D: Gebäude or F: bâtiment). Other translations refer to dwellings in the context of "dwelling units".

WG-AEN's recommendations

In the case of buildings, refer to the English version of the END text. In all cases where the term 'dwelling' is used in the END, this should be interpreted as meaning 'dwelling unit' – i.e. **as far as practicable calculations and estimates should be made for each individual dwelling unit.**

2.47 Determination of the number of dwelling units per residential building and population per dwelling unit

Issue

Annex VI of the END requires that, for major road, major railways and major airports, Member States provide information to the Commission on the estimated number of dwellings, and people that live in dwellings, that are in areas where the values of L_{den} are higher than 55, 65 and 75.

Discussion

If WG-AEN's recommended method for assigning noise exposure levels to the population living in multi-occupied residential buildings (section 2.45 / Toolkit 21 plus Toolkit 20) is used, the estimation of population per dwelling unit is not needed. However, numbers of dwelling units will still be needed to satisfy the reporting requirements of Annex VI of the END.

WG-AEN's recommendations

To determine or estimate the number of dwelling units and, if necessary, the population per dwelling unit refer to Toolkit 20.

2.48 Quiet areas in an agglomeration

Formal END Definitions:

Article 3 (l)

'quiet area in an agglomeration' shall mean an area, delimited by the competent authority, for instance which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source;

Discussion

In agglomerations, it is suggested that 'quiet' could be described by a value of L_{den} (or by another appropriate noise indicator), which has to be defined by the Member State. This would be more or less a quantitative acoustical definition.

It is generally accepted that in agglomerations quiet areas can only be relatively quiet because of the presence of major noise sources and noise that is caused by normal human activity in such densely populated areas. Once these 'relatively quiet' areas have been identified, the END requires that, in agglomerations with populations of more than 250,000, action plans to protect these areas shall be drawn up no later than 18th July 2008.

It is also generally accepted that noise mapping can be used to identify these areas. However, the END gives no advice on how to do this other than that given in Article 3(l), which merely identifies L_{den} as a possible indicator without suggesting limits. There appears to be no strong evidence for the use of a different indicator to L_{den} and no evidence in relation to appropriate levels for relatively quiet areas in any indicator. In addition, in agglomerations the L_{den} in relatively quiet areas will often be dominated by the weighted night-time noise and may thus be a misleading indicator. Consequently, the L_{den} may not be an appropriate indicator for setting targets for protecting or enhancing the quietness of such areas through action plans. For action plans it may be appropriate to set standards in terms of L_d and L_e. In some areas the use of a short-term indicator to deal with transient noises may also be appropriate in the development of effective action plans. For further information see the EC sponsored study that was carried out on the definition, identification and preservation of urban and rural quiet areas (Ref.16).

WG-AEN's recommendations

WG-AEN recommends that, whilst it is recognised that a quiet area in an agglomeration could be delimited by an indicator such as L_{den}, other criteria may need to be used. In addition, it may be that the use of absolute levels, in any indicator, is not appropriate for the delimiting of such areas. A relative approach may be more appropriate such as that recommended in the END (Annex VI (1.5)) for the identification of quiet facades.
It is also recognised that although a quiet area in an agglomeration could be, for example, a private garden or a large private estate, it is recommended that a special emphasis is placed on recreational areas normally accessible to the general public, which can provide respite from the high noise levels often experienced in busy urban environments.

It is strongly recommended that the protection of quiet areas should always be an integral part of the development of action plans for agglomerations and not treated merely as an 'add-on' to be addressed once other issues have been resolved.

2.49 Quiet areas in open country

Formal END Definitions:

Article 3 (m)

'quiet area in open country' shall mean an area, delimited by the competent authority, that is undisturbed by noise from traffic, industry or recreational activities;

Discussion

When a competent authority opts to delimit a quiet area in the open country, 'quiet' is considered to be 'undisturbed by noise from traffic, industry or recreational activities'. This is more or less a qualitative acoustical definition and, as a consequence, WG-AEN does not, at present, propose the use of formal criteria.

It should also be noted that the END does not require the acquisition of data on recreational noise, which can be quite significant in the open country. Furthermore, in the open country there is no requirement to acquire data on industrial noise and data on non-major roads, railways and airports. The EC is required by the END to submit to the European Parliament and the Council, no later than 18 July 2009, a report on the implementation of the END, which may include proposals regarding the protection of quiet areas in the open country.

WG-AEN's recommendations

WG-AEN recommends that in the interim period up until the EC reports on the implementation of the END in 2009, Member States should have regard to the

EC sponsored study that was carried out on the Definition, Identification and Preservation of Urban and Rural Quiet Areas (Ref.16) and should regard this as a starting point for defining quiet areas in rural environments.

Further research into quiet areas (in both urban and rural areas) needs to be undertaken at a European level. WG-AEN has made recommendations for such research (see Appendix 3).

Chapter 3 - The implications for accuracy of using some of the toolkits provided in Chapter 4

3.01 Background

Chapter 4 of this Position Paper presents a number of new toolkits, alongside some existing ones from Version1 (Ref.1), for which quantified accuracy statements are presented within the toolkits. These accuracy statements are the results of research work undertaken on behalf off the UK Government, in support of WG-AEN, entitled 'WG-AEN's Good Practice Guide And The Implications For Acoustic Accuracy' (Ref.2).

The quantified accuracy statements presented within the toolkits represent the likely level of acoustic uncertainty introduced into the result by the use of that toolkit option, with a 95% confidence level. It must be noted, that this represents the uncertainty of the total results only if all other input data is accurate. If there is uncertainty in any, or all, other input datasets, then the research concludes that total uncertainty in the receptor result level will be larger than any of the individual uncertainties.

The revised toolkits, with the stated accuracy implications, must be used with care and due consideration in order to understand that the uncertainty statement within the toolkit does not in itself provide a measure of the overall accuracy of the final results, but merely helps to understand, document and catalogue one of the areas of uncertainty within the overall process of noise mapping [14].

3.02 END requirements for accuracy

Absolute accuracy in the resultant value of a process is generally less important when only comparison studies are being carried out, or when only the identification of change is important, or when there are no targets, limits or other absolute milestone values.

Absolute accuracy is important when the assessment being undertaken is linked to targets, where comparison with limits is being undertaken, or when post result analysis is to be carried out to abstract results for other purposes. For example, the process of reporting results in noise level bands (as required by the END) can be described statistically as dividing the noise results by crisp boundaries into sets.

If we consider whether the END requires absolute accuracy, we can see that the requirements are:

---

[14] This chapter merely provides a brief overview of the background, purpose and context of the accuracy statements within the Toolkits. For a full appreciation of the results of the Accuracy Study (Ref.2) please consult all the reports relating to this Study which are available from the following website http://www.defra.gov.uk/environment/noise/research/index.htm.
Caution. It should be borne in mind that the Accuracy Study focuses on the recommended interim road traffic noise method, which is the French national method (Ref.3), and the UK national road traffic noise calculation method (Ref.4). It may not always be possible to apply the results to other methods.

- Reporting of limit values, absolute targets,
- Reporting of numbers of people in discrete 5 dB wide bands,
- Noise maps produced to inform development of Noise Action Plans, which means the assignment of budget,
- Noise map results to be post processed and linked to numbers of people.

The future use of the maps and their results could well include:

- Design of noise mitigation measures, which means public money expenditure,
- The post processing of the results to assess noise exposure across economic, social and ethnic groups to assess potential social exclusion issues.

All these required or potential uses rely upon the results of the mapping process to be accurate in an absolute sense, not just a relative sense. For this reason, understanding the sources and magnitude of the potential errors within the noise mapping process is a key factor in beginning to develop a strategy for the END which will be able to deliver all that is required of it; i.e. fit for purpose.

3.03 Achieving accuracy suitable for the END

This section summarises the several factors that affect the level of accuracy, which could be seen as appropriate for the results of the noise mapping process within the END. These could be identified as technical accuracy, economic impact and public perception.

Technical Accuracy

Stated simply, this comes down to whether the results are sufficiently accurate that dividing them into crisp (discrete) 5 dB(A) wide sets is an appropriate process. This use of the results tends to imply that we must have absolute accuracy within 2 dB(A) of the actual value.

The inaccuracy could be due to two different effects, which have different consequences for the ensuing process:

- Bias – all results tend to be too high or too low:
    - Noise contours are too big or too small
    - Follow on action planning will be fair and efficient as the hot spots (relatively high noise) are correctly identified
    - However, there may be too much or too little investment, too many or too few hot spots identified
- Error – uncertainty in results varies across the agglomeration:
    - Wrong placement of noise contours
    - Follow on action plan will be inefficient as hot spots may be incorrectly identified

Economic Impact

Over the past few years the economic cost/benefit of noise levels and noise mitigation has been investigated. This research can help to inform us of the potential cost to society of the assessment and analysis producing accurate results.

The “Valuation of Noise” Position Paper of EC Working Group - Health and Socio-Economic Aspects (WG-HSEA), 21 November 2003 (Ref.17) states:

> “For road transport, the (interim) use of the median value change in noise perceived by households of 25 € per dB (L_{den}), per household per year. The validity range of this interim value is between 50/55 L_{den} and 70/75 L_{den} and it should be adjusted as new research on the value of noise becomes available”.

This cost is said to apply at all initial noise levels, and regardless of the size of any change brought about.

Work by the Danish Environmental Protection Agency (Miljøstyrelsen) (Ref.18) states that, for houses exposed to levels greater than 55 dB, the house price:

- declines by 1.2%/dB near "ordinary" roads, and
- declines by 1.6% per dB near motorways.

It should also be considered desirable to achieve accurate and robust results simply because the European community will be investing so heavily into the process of noise mapping, noise actions plans, and noise mitigation. With 450 million EU residents, and possibly 60% within agglomerations, the initial noise maps may cost 0.2 to 1 € per inhabitant, before additional expenditure on the subsequent work.

Public Perception

Although this is apparently not the most obvious reason for accuracy, the END noise maps and subsequent action plans are probably the highest profile activity that the acoustics and noise control community has carried out, in the public’s eye.

Based upon previous experience, the generation of these results will probably lead to articles within the media. Articles may compare adjacent towns, states or countries.

In order that the industry’s credibility is upheld, good results and robust recommendations for action should be a desirable aim.

Chapter 4. Toolkits of solutions relating to specific challenges.

4.01 New Toolkits and Key for all Toolkits and Tools

The Accuracy Study (Ref.2) has provided six new toolkits (5, 6, 7, 11, 13 and 14) for this Position Paper. In addition, Toolkit 8 has been added. The six new toolkits include information on the accuracy implications of using the various tools they contain which is quantified in terms of dB. The Accuracy Study has also provided quantified accuracy implications of using the tools in Toolkits 2, 3, 4, 12, 15, and 16 which were contained in Version 1 of this document (where they were numbered as Toolkits 1, 2, 3, 8, 6, and 9 respectively) (Ref.1). In all toolkits where the accuracy implications of using the tools have been quantified in terms of dB, the following codes have been used.

Colour code to rate Tools					
complexity	**colour code**	**accuracy**	**colour code**	**cost**	**colour code**
simple	△	low	**> 5 dB**	inexpensive	△
-		-	**4 dB**	-	
-	◇	-	**3 dB**	-	◇
-	⬠	-	**2 dB**	-	⬠
-		-	**1 dB**	-	
sophisticated	⬡	high	**< 0.5 dB**	expensive	⬡

Where toolkits were not part of the Accuracy Study the following colour codes (accuracy symbols) have been used as in Version 1 of this document. **These colour codes (accuracy symbols) should only be compared to other colour codes (accuracy symbols) that are used within the same toolkit. That is, they should not be read across from one toolkit to another.**

Colour code to rate Tools					
complexity	**colour code**	**accuracy**	**colour code**	**cost**	**colour code**
simple	△	low	△	inexpensive	△
.	◇	.	`	.	◇
.	⬠	.	⬠	.	⬠
sophisticated	⬡	high	⬡	expensive	⬡

4.02 Toolkits – general issues

Toolkit 1: Area to be mapped		
Calculation type		**applicable tool**
Agglomeration	yes	use Tool 1.1
Major road	yes	use Tool 1.2
Major railway	yes	use Tool 1.2
Major airport	yes	use Tool 1.3

Tool 1.1: Agglomeration

The END states that an *"'agglomeration' shall mean 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."*
Therefore, the areas to be mapped are the areas of these agglomerations.

Tool 1.2: Major road or railway

Approach
estimate the

- distances[15] of the L_{den} = 55dB and L_{night} = 50dB noise contours from the noise source
- take the greater distance *d* then $d_1 = 1.5 * d$
- map the area up to the calculated distance (d_1)

Caution:
It should be noted that some calculation methods define a limited validity range in terms of maximum distance. In the case of XP S 31-133, the validity is limited to 800 m.

Tool 1.3: Major airport

Map the area out to the perimeter boundary of the airport and in addition map the area out to the L_{den} = 55 dB and L_{night} = 50 dB contours, if noise levels from the aircraft exceed these levels at the perimeter boundary.

[15] Suggestion: Use free field conditions to make a table or graph with distance based on the emission level of the source. This is likely to give an overestimation of the distance and thus provide a safety margin.

4.03 Toolkits - source related issues

Toolkit 2: Road traffic flow		
Available information		**applicable tool**
Traffic flow data separately for day, evening and night	yes / no	no further action
Traffic flow data per hour	yes / no	use Tool 2.1
Traffic flow data for two periods, day and night	yes / no	use Tool 2.2
Traffic flow data for weekday only	yes / no	use Tool 2.3
Traffic flow data for a full 24 hour day	yes / no	use Tool 2.2
Traffic flow data for 7 days (or longer period of time)	yes / no	use Tool 2.4
No traffic flow data available	yes	use Tool 2.5

Tool 2.1: Traffic flow data per hour			
Method	complexity	accuracy	cost
Sum the individual one hour figures for daytime, evening and night time periods separately		< 0.5 dB	

Tool 2.2: Traffic flow for two periods, day and night, or a full 24-hour day			
Method	complexity	accuracy	cost
If distribution data (official statistics) is available:			
Apply distribution to generate day, evening, night data		1 dB [16]	
If no distribution data (official statistics) available:			
Apply distribution along the lines of that in the examples given below:		1 dB [17]	
Examples For the default duration defined in the END: day (12h: 7^{00} - 19^{00}), evening (4h: 19^{00} - 23^{00}), night (8h: 23^{00} - 7^{00})			
o 16h daytime & 8h night time counts: o day = 12/16 of daytime counts o evening = 4/16 of daytime counts o night = 8/8 night time counts			

[16] Accuracy depends upon the accuracy of estimating the true day/evening values, here a 30% error margin has been assumed

[17] Accuracy heavily depends on the distribution: the method is highly accurate whenever data sampling period is equal to the required rating period; it is much more inaccurate for compound values calculated from night and day counts

o 14h daytime & 10h night time counts: o day = 12/14 of daytime counts o evening = (2/14 of daytime) + (2/10 of night time) o night = 8/10 of night time counts			
o 12h daytime & 12h night time counts o day = 12/12 of daytime counts o evening = 4/12 of night time counts o night = 8/12 of night time counts			
o 24h counts (important see footnote[18]) o day = 70% of counts o evening = 20% of counts o night = 10% of counts	◇	1 dB	△

Tool 2.3: Traffic flow for weekday only			
Method	complexity	accuracy	cost
Make traffic counts for each of the three periods: daytime, evening and night time at weekends	⬡	< 0.5 dB	⬡
Select sample roads and **do traffic counts** there; **extrapolate distribution** (weekday to weekend) **to other roads** of same type	⬡	< 0.5 dB	⬠
Use official traffic flow statistics for different road types published by recognised bodies or authorities to **extrapolate distribution** (weekday to weekend) **to other roads**	◇	< 0.5 dB	△
Use other traffic flow statistics for different road types **to extrapolate distribution** (weekday to weekend) **to other roads**	◇	< 0.5 dB	△
Use value of weekday also for weekend	△	1 dB	△

Tool 2.4: Traffic flow for 7 days (or longer period of time)			
Method	complexity	accuracy	cost
Distribute equally by dividing the traffic count by the number of days of the time period, then use Tool 2.2	△	1 dB	△

[18] These figures are based on an analysis of several years of traffic counts obtained with a permanent automatic hourly traffic counting station installed on a major road in Berlin/Germany and are only provided as an **example**. As with many examples provide in this Position paper the situation will vary from country to country and, in this case, possibly for different types of road. For instance, in Demark traffic counts on minor roads show a distribution of 80% during the 12 daytime hours, 10-12%in the evening and 8-10% during the night.

Tool 2.5: No traffic flow data available						
Method				complexity	accuracy	cost
Make traffic counts for each of the three periods: daytime, evening and night time				⬡	< 0.5 dB	⬡
Select sample roads and **do traffic counts** there; **extrapolate to other roads** of same type				⬡	2 dB	⬠
Use official traffic flow data for **typical** road types.				◇	4 dB	△
Use other traffic flow data for **typical** road types**.**				◇	4 dB	△
Use **default values,** such as:				△	4 dB	△
Road type	traffic[19]					
	day	**evening**	**night**			
Dead-end roads	175	50	25			
Service roads (mainly used by residents living there)	350	100	50			
Collecting roads (collecting traffic from service roads and leading it to & from main roads)	700	200	100			
Small main roads	1,400	400	200			
Main roads	**Must undertake traffic counts or produce flows from a traffic model. See section 2.10**			⬡	< 0.5 dB	⬠

[19] Number of vehicles for the given period of time (not hourly data)

Toolkit 3: Average road traffic speed		
Available information		**applicable tool**
Speed for day, evening and night	yes / no	no further action
Speed for each hour of the day	yes / no	use Tool 3.1
Speed for day and night	yes / no	use Tool 3.2
Traffic speed for an 18-hour day or a full 24-hour day (or longer period of time)	yes / no	use Tool 3.3
Speed for weekdays	yes / no	use Tool 3.4
No speed data	yes	use Tool 3.5

Tool 3.1: Speed for each hour of the day			
Method	**complexity**	**accuracy**	**cost**
Calculate arithmetically the average speed for the different periods (day, evening, night)	△	< 0.5 dB	△

Tool 3.2: Speed for day and night			
Method	**complexity**	**accuracy**	**cost**
Use value of daytime for day and evening Use value of night time for night	△	< 0.5 dB	△

Tool 3.3: Speed for an 18-hour day or a full 24-hour day (or longer period of time)			
Method	**complexity**	**accuracy**	**cost**
Use value for day and evening Use speed limit for night period	△	1 dB	△

Tool 3.4: Speed for weekdays			
Method	**complexity**	**accuracy**	**cost**
Use Tool 3.5 to gather weekend data	depends on method used		
Use weekday data also for weekend	△	< 0.5 dB	△

Tool 3.5: No speed data			
Method	complexity	accuracy	cost
Measure vehicle speeds by means of radar or other suitable technology		< 0.5 dB	
Measure time vehicles take to travel along a road section of known length and calculate average traffic speed		< 0.5 dB	
Determine average traffic speed by **driving in the average traffic flow**		1 dB	
Use the **speed limit** (e.g. from traffic signs)		2 dB	
Make an **assumption** of average traffic speed based on experience from similar road types		2 dB	

Toolkit 4: Composition of road traffic		
Available information[20]		**applicable tool**
Percentage of heavy vehicle– separately for day, evening and night	yes / no	no further action
Percentage of heavy vehicles for each hour over a 24 hour period	yes / no	use Tool 4.1
Percentage of heavy vehicles for two periods - day and night	yes / no	use Tool 4.2
Percentage of heavy vehicles for a full 24-hours day (or longer period of time)	yes / no	use Tool 4.3
Percentage of heavy vehicles weekday only	yes / no	use Tool 4.4
No heavy vehicle data available	yes	use Tool 4.5

Tool 4.1: Percentage of heavy vehicles data for each hour over a 24 hour period			
Method	complexity	accuracy	cost
Derive heavy vehicle counts from percentages and then sum the individual one-hour heavy traffic counts for daytime, evening and night time periods separately and derive heavy vehicle percentages from total traffic flows for those periods.	◇	< 0.5 dB	◇

[20] This Toolkit only refers to two categories of vehicle. Some calculation methods may use additional categories.

Tool 4.2: Percentage of heavy vehicles data for day and night			
Method	**complexity**	**accuracy**	**cost**
Use value of daytime for day and evening Use value of night time for night		< 0.5 dB	
If official distribution data are available:			
Apply distribution to generate day, evening, night data		< 0.5 dB [21]	
If no official distribution data is available:			
Apply a distribution similar to that in the examples given below–		< 0.5 dB [22]	
<u>**Examples**</u> [23]**:** Default duration defined in the END: day (12h: 7^{00} - 19^{00}), evening (4h: 19^{00} - 23^{00}), night (8h: 23^{00} - 7^{00}) If the heavy traffic is given as a percentage convert it to absolute numbers first and then convert back to a percentage after the numbers have been allocated by undertaking one of the following processes.			
o <u>16h daytime & 8h night time counts:</u> o day = 12/16 of daytime counts o evening = 4/16 of daytime counts o night = 8/8 night time counts			
o <u>14h daytime & 10h night time counts:</u> o day = 12/14 of daytime counts o evening = (2/14 of daytime) + (2/10 of night time) o night = 8/10 of night time counts			
o <u>12h daytime & 12h night time counts</u> o day = 12/12 of daytime counts o evening = 4/12 of night time counts o night = 8/12 of night time counts			

[21] Accuracy depends upon the accuracy of estimating the true day/evening values; here a 25% error margin has been assumed.

[22] Accuracy heavily depends on the distribution: the method is highly accurate whenever data sampling period is equal to the required rating period; it is much more inaccurate for compound values calculated from night and day counts.

[23] These are only **examples**. The situation will vary from country to country.

Tool 4.3: Percentage of heavy vehicles data for a full 24-hours day (or longer period of time)			
Method	**complexity**	**accuracy**	**cost**
If distribution data (official statistics) is available:			
Apply distribution to generate day, evening, night data		< 0.5 dB	
If no distribution data (official statistics) is available:			
Make traffic counts on all roads		< 0.5 dB	
Make sample traffic counts and generate distribution, then **apply distribution** to generate day, evening, night data		< 0.5 dB	
Use default values such as those in Tool 4.5 to generate distribution, then **apply distribution** to generate day, evening, night data		1 dB	
Use value for day, evening and night		1 dB	

Tool 4.4: Percentage of heavy vehicles data for weekday only			
Method	**complexity**	**accuracy**	**cost**
Make traffic counts for each of the three periods: daytime, evening and night time		< 0.5 dB	
Select sample roads and **do traffic counts** there; **extrapolate distribution** (weekday to weekend) **to other roads** of same type		< 0.5 dB	
Use official statistical heavy vehicle rates for different road types published by recognised bodies or authorities to **extrapolate distribution** (weekday to weekend)		< 0.5 dB	
Use other statistical heavy vehicle rates for different road types to **extrapolate distribution** (weekday to weekend)		< 0.5 dB	
Use weekday data also for weekend		< 0.5 dB	

Tool 4.5: No heavy vehicle data available			
Method	complexity	accuracy	cost
Make traffic counts for each of the three periods: daytime, evening and night time		< 0.5 dB	
Select sample roads and **do traffic counts** there; **extrapolate** to other roads of same type		< 0.5 dB	
Use official statistics for heavy vehicle rates of different road types published by recognised bodies or authorities		1 dB	
Use other statistical heavy vehicle rates for different road types		1 dB	
Use **default values,** for example [24]: (see table below)		2 dB	

Road type	traffic		
	day	evening	night
Dead-end roads	2 %	1 %	0 %
Service roads (mainly used by residents living there)	5 %	2 %	1 %
Collecting roads (collecting traffic from service roads and leading it to & from main roads)	10 %	6 %	3 %
Small main roads	15 %	10 %	5 %
Main roads	20 %	15 %	10 %
Major main roads	20 %	15 %	10 %
Trunk roads	20 %	20 %	20 %
Motorways	25 %	35 %	45 %

[24] These are only **examples**. The situation will vary from country to country.

Toolkit 5: Road surface type [25]		
Available information		**applicable tool**
Acoustical road surface parameters are known by measurement	yes / no	no further action
Acoustical measurements of the road surfaces	yes / no	Tool 5.1
Surface type for road segment based on physical properties	yes / no	Tool 5.2
Road surface type based on visual inspection	yes / no	Tool 5.3
Road surface type based on road type	yes / no	Tool 5.4
No road surface data known	yes	Tool 5.5

Tool 5.1: Acoustical measurements of the road surfaces			
Method	complexity	accuracy	cost
CPX measurement			
Perform a Close Proximity Measurement (CPX) to determine the acoustical road surface parameters. The main advantage of a CPX measurement is that variations in the quality along the road can be measured. Also the aging effect of the road surface can be taken into account. (ISO/CD 11819-2)		< 0.5 dB	
SPB measurement			
Perform a statistical pass-by (SPB) measurement to determine the acoustical road surface parameters. The correction of the measured road surface is assumed to be representative for the complete road. (or for the complete road network where this road category is present. (ISO 11819-1)		< 0.5 dB	

[25] Most calculation methods used within the EU use one attribute for the road surface. However, the UK calculation method CRTN (Ref.4) has two variables, the road surface material and the texture depth. The Accuracy Study (Ref. 2) contains a Toolkit for the CRTN texture depth.

Tool 5.2: Surface type for road segment based on physical properties

Method	**complexity**	**accuracy**	**cost**
Categorisation on physical parameters			
This categorisation is based on the chipping size, porosity and type of pavement (asphalt, concrete or cobblestones/ pavement stones) The road corrections are assigned to every road segment according to the following table[26]:		1 dB	

Uneven pavement stones	PS uneven	4.8	
Even pavement stones	PS even	3.1	
Cement concrete, transversely brushed	CCB tr	1.1	
Cement concrete, longitudinally brushed	CCB lo		
Exposed aggregate	EA		
Burlap treated cement concrete	CC burlap		
Surface Dressing 0/11	SD		
Grip-surface	GR		
Hot rolled asphalt	HRA		
Gussasphalt	GA	0.0	
Asphalt concrete 0/16	AC 0/16		
Asphalt concrete 0/11	AC 0/11		
Drainage asphalt more than 5 years old	DA 0/11 g5		
Stone mastic asphalt 0/11	SMA 0/11		
Drainage asphalt 0/16, 3-5 years old	DA 0/16 3-5	-2.7	(-1.7)
Drainage asphalt 0/11, 3-5 years old	DA 0/11 3-5		
Drainage asphalt 0/8, 3-5 years old	DA 0/8 3-5		
Drainage asphalt 0/16, less than 3 years old	DA 0/16 k3		
Drainage asphalt 0/11, less than 3 years old	DA 0/11 k3		
Drainage asphalt 0/8, less than 3 years old	DA 0/8 k3		
Twin layer drainage asphalt, more than 5 years old	DA twin g5	-3.5	(-2.5)
Twin layer drainage asphalt, 3-5 years old	DA twin 3-5		
Twin layer Drainage asphalt, less than 3 years old	DA twin k3		
Porous Thin Layers 0/8	Thin 0/8		
Porous Thin Layers 0/6	Thin 0/6		
Remark: for 50km/h roads with drainage or low noise asphalt -1.7 and -2.5 dB			

Tool 5.3: Road surface type based on visual inspection

Method	**complexity**	**accuracy**	**cost**
Apply noise corrections based on visual inspection of asphalt/concrete/porous or cobblestones surfaces.		1 dB	

Uneven pavement stones	PS uneven	4.8	
Even pavement stones	PS even	3.1	
Cement concrete / Rough asphalt	Con / Ror	1.1	
Smooth asphalt (reference)	Ref	0.0	
Drainage asphalt < 5 years	DA	-2.7	(-1.7)
Low noise porous asphalt	LN P	-3.5	(-2.5)
Remark: for 50km/h roads with drainage or low noise asphalt -1.7 and -2.5 dB			

[26] In the notation "0/11", the digits 11 denote the maximum chipping size in mm.

Tool 5.4: Road surface type based on road type

Method	complexity	accuracy	cost
Divide all roads into different categories and apply for every road type the default pavement most likely for this kind of road.		2 dB	

Example Only

Type of road	Default pavement
dead-end roads	stones
service roads	stones
collecting roads	asphalt
small main roads	asphalt
main roads	asphalt
major main roads	concrete/porous/asphalt
trunk roads	concrete/porous/asphalt
motorways	concrete/porous/asphalt

Every region or Member State should make its own classification.

Use Tool 5.2 or Tool 5.3.

Tool 5.5: No road surface data known

Method	complexity	accuracy	cost
Use dense asphalt for every road, correction is 0 dB.		3 dB	

Toolkit 6: Speed fluctuations at road junctions		
Available information		**applicable tool**
Road sections with decelerating and accelerating traffic	yes / no	no further action
Location of junctions with traffic lights are known	yes / no	Tool 6.1
No data available	yes	Tool 6.2

Tool 6.1: Location of junctions with traffic lights are known			
Method	complexity	accuracy	cost
If driving directions are separated and known:			
Divide the roads into segments with accelerating, decelerating and continuous traffic flow The length of a road segment with accelerating/decelerating flow is: decelerating: 3 * V (in m, before the centre of the junction) accelerating: 2 * V (in m, beyond the centre of the junction) where V is the speed limit in km/h		< 0.5 dB	
If driving directions are not separated or not known:			
No distinction between accelerating, decelerating and continuous traffic flow (i.e. use continuous)		1 dB	

Tool 6.2: No data available			
Method	complexity	accuracy	cost
Make **on-site visits** and detect junctions with traffic lights, then use Tool 6.1		< 0.5 dB	
Use **aerial photographs** for detection of junctions with traffic lights, then use Tool 6.1		< 0.5 dB	
Use computer algorithms for **automatic detection** of level intersections of roads, each having a minimum traffic flow of 2500 vehicles per 24 hours. Then use Tool 6.1		< 0.5 dB	
No distinction between accelerating, decelerating and continuous traffic flow (i.e. use continuous)		1 dB	

Toolkit 7: Road gradient		
Available information		**applicable tool**
Road gradient for each road segment	yes / no	no further action
Ground elevation model	yes / no	Tool 7.1
Location of hills, tunnels and viaducts	yes / no	Tool 7.2
No data available	yes	Tool 7.3

Tool 7.1: Ground elevation model			
Method	complexity	accuracy	cost
If a ground elevation model is known:			
The road gradient can be calculated directly from the ground elevation model.		< 0.5 dB	
If a three dimensional road profile is available:			
The road gradient can be calculated from the road profile.		< 0.5 dB	

Tool 7.2: Location of hills, tunnels and viaducts			
Method	complexity	accuracy	cost
In some situations a small number of spot heights may be available on the road, or surrounding landscape, but insufficient to build a full ground model. Using this information measure or estimate the height difference along a known distance and calculate the ratio to determine the slope. For roads or ramps leading to bridges/viaducts or tunnels, this can also be done by taking two cross sections at the beginning and the end of the slope.		< 0.5 dB	
When only the location of hills, ramps, bridges/viaducts or tunnels are known. The road gradient should be estimated; the default values for slopes and viaducts are 5 to 15 percent. From visual inspections one should choose one of the following road elevation values **Visual estimation** – **Gradient** gradual slope – 5 % moderate slope – 10 % steep slope – 15 %		< 0.5 dB	
The slope may be measured [27]. This can be combined with a general measurement to determine the road height to reduce the cost of the measurement.		< 0.5 dB	

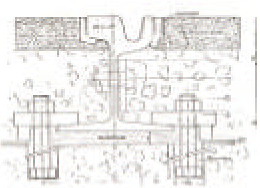
[27] Methods such as GPS trajectory surveys, airborne laser scanning (Lidar), remote sensing and photogrammetry could be utilised.

Tool 7.3: No data available			
Method	complexity	accuracy	cost
The slope may be measured [28]. This can be combined with a general measurement to determine the road height to reduce the cost of the measurement.	◇	< 0.5 dB	⬠
When no data is available the default parameter is 0 %.	△	3 dB	△

[28] Methods such as GPS trajectory surveys, airborne laser scanning (LIDAR), remote sensing and photogrammetry could be utilised.

Toolkit 8: Sound power level of trams and light-rail vehicles		
Available information **(Note. It may be necessary to use more than one tool)**		**applicable tool**
Acoustical sound power level per unit of rolling noise, squeal noise and impulsive noise on the used rail network as a function of speed and for the different used rail constructions and the representative rail roughness.	yes / no	no further action
Acoustical sound power level per unit of rolling noise, on the used rail network as a function of speed and for the different used rail constructions and the representative rail roughness are known. Correct for squeal and impulsive noise.	yes / no	Tool 8.1
Acoustical sound power level per unit of rolling noise, on the used rail network as a function of speed. Correct type and rail construction	yes / no	Tool 8.2
Acoustical sound power level per unit of rolling noise, on the used rail network at a certain speed.	yes / no	Tool 8.3
No data known	yes	Tool 8.4

Tool 8.1: Corrections for squeal noise and impulsive noise (may be used when the calculation method does not contain such corrections)			
Method	complexity	accuracy	cost
Make observations during a representative dry period on curves with a radius < 100 metres If no squeal noise: no correction Squeal noise occurs: correction of up to +12 dB(A) if it occurs with all vehicles (a smaller correction should be applied if it occurs less often). This is a correction (based on experience), which should be applied to the normal source emission level. The correction to be applied over the section of the curve where squeal noise occurs.			
Where rail joints are found: If no impulsive noise: no correction Impulsive noise occurs: correction of +3 dB(A). This is a correction (based on experience), which should be applied to the normal source emission level. The correction to be applied for the line source 30 metres before and after the rail joint.			

Tool 8.2: Corrections for rail type and rail construction			
Method	complexity	accuracy	cost
Regular rail in ballast: no correction Grooved rail in ballast: correction +2 dB(A) Rail in asphalt or concrete (as shown below): correction +3 dB(A) (Note. Propagation calculations may need to take account of the  reflective surface in which the rail is placed)			

Tool 8.3: Use speed dependency			
Method	complexity	accuracy	cost
Make corrections for the actual vehicle speed on different track sections. For calculating the sound power level use 30.Log (v_{actual}/v_{ref}) or for calculating the equivalent emission/immission use 20.Log (v_{actual}/v_{ref})[29]			

Tool 8.4: No data known			
Method	complexity	accuracy	cost
Measure the acoustical sound power level per unit of rolling noise, as a function of speed and for the different rail constructions and the representative rail roughness.			
Measure the acoustical sound power level per unit for squeal noise and impulsive noise on the rail network as a function of speed and for the different used rail constructions. (Measurement on squeal noise are very complicated and they take a long time)			
For regular rail in ballast use an SEL at 25 m of 70 dB per bogie (2 axles) For grooved rail in asphalt or concrete: use an SEL at 25 m of 70 dB per bogie (2 axles), independent of the rail construction, and use the correction given in Tool 8.2 For both rail constructions and for no regular maintenance of the rail roughness: make a correction of +2 dB			

[29] The difference between the formulas 30.Log (v_{actual}/v_{ref}) and the 20.Log (v_{actual}/v_{ref}) has to do with the exposure time. The sound power has an empiric relation to the speed with a 3rd power (v^3). For a receiver point of view a moving vehicle passing on a higher speed the exposure time will be shorter. This relation is -10.Log (T) where T is the exposure time. A shorter exposure time w ill result in a (relative) lower equivalent noise level. This (lower) has an empiric relation to the speed of (30-10).Log (v_{actual}/v_{ref}).

Toolkit 9: Train (or tram) speed			
Method	**complexity**	**accuracy**	**cost**
Reliable train speeds are **available from the owner of the tracks**			
Reliable train speeds are **available from the operators of the trains**			
Measure train speeds			
Use timetables and distances to calculate an average speed (may not be possible for freight trains)			
Take the minimum of the following two values: • maximum train speed • maximum track speed			

Toolkit 10: Sound power levels of industrial sources		
Available information		**applicable tool**
Different sound power levels that apply to the day, evening and night periods	yes / no	no further action
Different sound power levels that apply to each hour of operation	yes / no	Use Tool 10.1
Sound power levels that apply to two periods (day and night)	yes / no	use Tool 10.2
Sound power levels that apply to a full 24-hour day (or longer period of time)	yes / no	use Tool 10.3
Sound power levels known, but applicable hours not known	yes / no	use Tool 10.4
Sound power levels unknown	yes	use Tool 10.5

Tool 10.1: Different sound power levels that apply to each hour of operation			
Method	**complexity**	**accuracy**	**cost**
Calculate logarithmically the average sound power level for the different periods (day, evening and night)			

Tool 10.2: Sound power levels for two periods (day and night)			
Method	**complexity**	**accuracy**	**cost**
Check operating times and use relevant sound power level when facility is in use			
Use the sound power level of daytime for day. Use the sound power level of nighttime for night. If factory operates evenings [or part of the evening], use daytime value		`	

Tool 10.3: Sound power levels for a full 24-hour day			
Method	**complexity**	**accuracy**	**cost**
Check operating times and use value when facility is in use			
Use the 24 hour sound power level for day, evening and night			

Tool 10.4: Sound power levels known, but applicable hours not known			
Method	**complexity**	**accuracy**	**cost**
Check operating times and use value when facility is in use			
Use the available sound power level for day, evening and night			

Tool 10.5: Sound power levels unknown			
Method	complexity	accuracy	cost
Obtain sound power levels from **source operator**			
Determine sound power levels using ISO 8297			
Use input data contained in an **EIA** (Environmental Impact Assessment)			
Use nationally defined **default source sound power levels**			
Use nationally defined **maximum permissible sound power levels per unit of surface area**			
If Directive 2000/14/EC provides limiting values for source under consideration, use these values			
Use **public databases** (examples see Table 1 and Table 2). Also see IMAGINE Project (Ref.19) which is developing a database			
Use the following **default values**:			

Type of industry	Default value for L_W'' (/m^2)		
	day	evening	night
Area with heavy industries	65 dB(A)	65 dB(A)	65 dB(A)
Area with light industries	60 dB(A)	60 dB(A)	60 dB(A)
Area with commercial uses	60 dB(A)	60 dB(A)	45 dB(A)
Ports	65 dB(A)	65 dB(A)	65 dB(A)

Table 1: Sample databases for individual industrial sound sources with sound power levels for entire companies.

Database	Description	Address
Directive 2000/14/EC	Sound power levels of equipment used outdoors: Art 12, limiting values for different types of machines.	http://europa.eu.int/comm/environment/noise
Report UBA-94-102	Noise emission Measurement – Limit values – State of the art Chapter 2.2.1	Umweltbundesamt (Federal Environmental Agency) Austria
Lärm Bekampfung 88	Tendenzen – Probleme – Lösungen	Umweltbundesamt (Federal Environmental Agency) Germany
British Standard 5228 part 1 – 1997	Noise and vibration control on construction and open sites.	British Standards Institution UK
Eurovent Directory of Certified products	Certified Lw for Air Conditioners and Cooling Equipment.	Eurovent Certification Company France

Table 2: Non-comprehensive list of available databases with sound power levels for entire companies.		
Database	**Description**	**Address**
Kentallen Industrie	Mean value of Lw" on the basis of a large number of situations	i-kwadraat c/o DCMR Milieudienst Rijnmond The Netherlands E-mail : si2@DCMR.nl http://www.xs4all.nl/~rigolett
DGMK Project 209	Specific A-weighted Sound Power Level of Refineries and Petrochemical Works	DGMK Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V Germany
DGMK Project 308	Evaluation of the immission-relevant A-weighted sound power level of an open plant from sound measurements inside the plant.	
DGMK Project 446	Community noise levels of existing refineries and petrochemical plants.	
Report UBA-94-102	Noise emission Measurement – Limit values – State of the art Chapter 2.2.2	Umweltbundesamt (Federal Environmental Agency) Austria
Monographien Band 154	Schallemission von Betriebstypen und Flächenwidmung	
DIN18005 Part 1	Noise abatement in town planning; calculation methods	http://www2.din.de/
AV-Ecosafer	L_W measured on site for different types of open chemical and petrochemical installations	AV-Ecosafer nv Belgium
Defra	Update of noise database for prediction of noise on construction and open sites (HMSO 2005)	http://www.defra.gov.uk/

4.04 Toolkits – propagation related issues

Toolkit 11: Ground elevation close to the source		
Available information		**applicable tool**
Digital terrain model including cuttings and embankments	yes / no	no further action
GPS height of a road	yes / no	Tool 11.1
Cross sections	yes / no	Tool 11.2
Default height of embankment	yes / no	Tool 11.3
No data available	yes	Tool 11.4

Tool 11.1: GPS height of a road			
Method	complexity	accuracy	cost
The road height can be determined by measurement[30]. This can be combined with an estimation of global ground height to determine the height of the embankment or cutting.		< 0.5 dB	
The height of objects which can screen noise propagation should be determined, this can also be done by measurement[30] or alternatively by visual estimation of the height above local terrain.		< 0.5 dB	

Tool 11.2: Cross sections			
Method	complexity	accuracy	cost
If cross sections from a road are available, the road height can be determined from these cross sections.		1 dB	

Tool 11.3: Default height of embankment			
Method	complexity	accuracy	cost
In a more or less flat situation the main parameter is the height of the road above or under local terrain, this is the height of the embankment or cutting. This height can be determined by visual inspection. The default height of an embankment crossing a road or a railway is given in the table below:		2 dB	

crossing item	height
Railroad	8.0 metres
major road	6.0 metres
local road	4.0 metres

[30] Methods such as GPS trajectory surveys, airborne laser scanning (LIDAR), remote sensing and photogrammetry could be utilised.

Tool 11.4: No data available			
Method	complexity	accuracy	cost
Sources are situated on an embankment with a default height e.g. 1.5 metres. The individual Member States can decide on a default value. The surrounding terrain is considered (approximately) flat	△	**> 5 dB**	△

Toolkit 12: Cuttings and embankments	
Available information	**applicable tool**
Digital information on cuttings and embankments	use Tool 12.1
The location and height of cuttings and embankments but these are not in the digital site model	use Tool 12.2
The location and height of cuttings and embankments are unknown	use Tool 12.3

Tool 12.1: Digital information on cuttings and embankments			
Method	complexity	accuracy	cost
Incorporate information on cuttings and embankments in digital site model and then use 3D visualising tools to carefully check for inconsistencies and discontinuities		< 0.5 dB	

Tool 12.2: The location and height of cuttings and embankments are not in the digital site model			
Method	complexity	accuracy	cost
Approach for cuttings: Digitise contour lines along the top of the cutting, on both sides, to model the nearby area. Digitise contour lines along the bottom of the cutting, on both sides, to model the railway or road area		< 0.5 dB	
Approach for embankments: Digitise contour lines along the top of the embankment, on both sides, to model the railway or road area. Digitise contour lines along the bottom of the embankment, on both sides, to model the nearby area		< 0.5 dB	

Tool 12.3: The location and height of cuttings and embankments are unknown			
Method	complexity	accuracy	cost
In all cases			
Undertake surveys to locate embankments and cuttings		< 0.5 dB	
Then either			
Use surveying techniques to obtain the necessary position & height data		< 0.5 dB	
Check with official bodies to see if they can provide **paper maps** of embankments and cuttings Continue with tool 12.2.		< 0.5 dB	
Estimate the **height** from the site visit **then digitise** the **position** from **aerial photos:** Continue with tool 12.2		1 dB	
Estimate the **position and height** from the site visit: Continue with tool 12.2		1 dB	
Ignore cuttings if no relevant sources are located in these cuttings		1 dB	

Toolkit 13: Ground surface type	
Available information	**applicable tool**
Detailed geometry of reflective and absorptive surfaces (yes / no)	no further action
Land use classification (yes / no)	Tool 13.1
Classification of urban/suburban and rural (yes / no)	Tool 13.2
No data available (yes)	Tool 13.3

Tool 13.1: Land use classification			
Method	complexity	accuracy	cost
From land usage maps in GIS, the ground surface can be divided in classes. To each of these ground usage classes a default ground factor can be assigned, where 1.0 is absorptive.		1 dB	

Land usage	ground factor
forest	1.0
agriculture	1.0
park	1.0
heath land	1.0
paving	0.0
urban	0.0
industrial	0.0
water	0.0
residential	0.5

Tool 13.2: Classification of urban/suburban and rural			
Method	complexity	accuracy	cost
For urban areas the ground surface is default acoustically reflective, for suburban areas the ground surface is default 50% acoustically reflective and for rural areas the ground surface is by default absorbing. This can be extended with extra information for adding water in rural areas and forests/parks and sports grounds in urban areas		2 dB	

Tool 13.3: No data available			
Method	complexity	accuracy	cost
Use reflective ground everywhere as a worst-case default		3 dB	

Toolkit 14: Barrier heights near roads		
Available information		**applicable tool**
Height of the barrier above the road	yes / no	no further action
Height of the barrier above ground height at the barrier	yes / no	Tool 14.1
Visual estimation of barrier height	yes	Tool 14.2

Tool 14.1 Height relative to road			
Method	**complexity**	**accuracy**	**cost**
Subtract the height of a road above or the ground height at the barrier to get the height of the barrier above road level		< 0.5 dB	
Derive the height of a barrier from a drawing with a cross section		< 0.5 dB	

Tool 14.2: Visual estimation of height			
Method	**complexity**	**accuracy**	**cost**
Visual inspection of the barrier height relative to the road surface (preferably from roadside)		1 dB	
Divide barriers into classes and take the default barrier height from the classification **Example:**		2 dB	

class	height
low	1.5 metres
medium	3.0 metres
high	6.0 metres

Toolkit 15 Building heights		
Available information		**applicable tool**
Building heights	yes / no	use heights
Number of storeys	yes / no	use Tool 15.1
No information	yes	use Tool 15.2

Tool 15.1: Number of storeys available			
Method	**complexity**	**accuracy**	**cost**
Multiply number of storeys with the average storey height (e.g. 3 metres)		1 dB	

Tool 15.2: No information available			
Method	**complexity**	**accuracy**	**cost**
Use **aerial photos to estimate height**		< 0.5 dB	
Make **on-site visits** and **count storeys**; then use Tool 15.1		1 dB	
Use **aerial photos** to estimate number of storeys then use Tool 15.1		1 dB	
Use **default heights** for different types of buildings[31]		2 dB	
Use a **default height** for all buildings (e.g. 8 metres)		3 dB	

[31] To identify different building types use the surface area covered by the building and the property boundaries or make site visits

Toolkit 16: Sound absorption coefficients a_r for buildings and barriers

Method		complexity	accuracy	cost
Use absorption coefficients if known			< 0.5 dB	
Measure absorption coefficients			< 0.5 dB	
Use nationally defined default absorption coefficient values			2 dB	
Use the following default values:			1 dB	
Structure	**Suggested a_r**			
Completely reflecting (e.g. glass or steel)	0,0			
Plane masonry wall, reflecting noise barrier	0,2			
Structured masonry wall (e.g. building with balconies and oriels)	0,4			
Absorbing wall or noise barrier	See manufacturer's data. If unavailable use 0.6			

Toolkit 17: Occurrence of favourable sound propagation conditions				
Method		complexity	accuracy	cost
Use local meteorological data				
Use national regulations/standards (e.g. NMPB defines values for different regions of France)		depends on the regulations		
Use national meteorological default values				
Use the following **default values**:				
Time period	**Average probability of occurrence during the year**			
Day	50% favourable propagation conditions			
Evening	75% favourable propagation conditions			
Night	100% favourable propagation conditions			

Toolkit 18: Humidity and temperature [32]			
Method	complexity	accuracy	cost
Use actual humidity and temperature values if available			
Acquire humidity and temperature data			
Use nationally defined default values (e.g. the French XP S 31-133 standard permits the use of the default values of 15° C and 70% relative humidity)			

[32] Humidity and temperature only has a small influence on noise levels compared to the influence of other parameters (e.g. prevailing wind, temperature inversions and quality of source data).

4.05 Toolkits - receiver related issues

Toolkit 19: Assignment of population data to residential buildings [33]		
Available information		**applicable tool**
Number of residents in each building	yes / no	use Tool 19.4
Number of residents in the mapping area or sub-areas	yes / no	use Tool 19.1
No information available	yes	use Tool 19.2

Tool 19.1: Number of residents of the mapping area or sub-areas			
Method	**complexity**	**accuracy**	**cost**
• Determine the number of residents in each residential building • Compare the total with national or regional population statistics and, if required, realign individual dwelling population figures to total population figures using Tool 19.4			
If the entire residential floor area of the mapping area, or sub-areas, is known:			
• Divide the entire residential floor area of the mapping area, or sub-area, by number of residents = **floor area/resident** • Obtain building area from a GIS and multiply this by the number of storeys (if not known, use Tool 19.3) = **residential floor area of the building** • Divide **residential floor area of the building** by **floor area/resident** = **number of residents of building** • Compare with national or regional population statistics and, if required, realign individual dwelling population figures to total population figures using Tool 19.4			
If the entire residential floor area of the mapping area, or sub-areas, is unknown:			

[33] The estimation of population per dwelling unit is described in Toolkit 20

• Find **floor area/resident** from national statistics (if not known, use Tool 19.2) • Obtain building area from a GIS and multiply this by the number of storeys (if not known, use Tool 19.3) = **residential floor area of building**[34] • Divide **residential floor area of building** by **residential floor area /resident** = **number of residents of building** • Compare with national or regional population statistics and, if required, realign individual dwelling population figures to total population figures using Tool 19.4			

Tool 19.2: No information available			
Method	complexity	accuracy	cost
• Count number of residents in each building • Compare with national or regional population statistics and, if required, realign individual dwelling population figures to total population figures using Tool 19.4			
• Make estimates of the average number of residents living in different types of buildings[35] (such as detached houses, blocks with different numbers of storeys, etc.) • Conduct limited surveys and prepare list with building types and estimated numbers of residents • Compare with national or regional population statistics and, if required, realign individual dwelling population figures to total population figures using Tool 19.4			

Tool 19.3: Number of storeys in each building			
Method	complexity	accuracy	cost
Obtain the number of storeys in each residential building from GIS data			
Determine the number of storeys by site survey			
Determine the number of storeys by estimation from building height. For example divide building height by 3 metres to get the number of storeys			

[34] Multi-storey buildings may have mixed commercial/residential purposes (for example, the ground floor consisting of shops while upper floors consist of residences). It may be useful to consider this fact when assigning population to dwellings.

[35] To identify different building types use surface covered by the building and the property boundaries or make site visits

Tool 19.4: Realigning individual dwelling population figures to total population figures			
Method	**Complexity**	**accuracy**	**cost**
• Determine the **correct total population** in the area to be mapped from national statistics • Sum the **total registered population** by = **number of residents in building * number of buildings** • Determine **Normalisation factor** to align the total registered population to the correct total population = **total registered population**/**correct total population** • Determine the **actual number of residents in building** by adjusting the number of residents in building by the Normalisation factor[36] = **number of residents in building * Normalisation factor**			

[36] If the normalisation factor is not significantly different than 1.0, then it may be acceptable to avoid this last step, as the errors introduced will be small.

Toolkit 20: Determination of the number of dwelling units per residential building and the population per dwelling unit	
Information required	**applicable tool**
Number of dwelling units per residential building	use Tool 20.1
Population per dwelling unit	use Tool 20.2

Tool 20.1: Number of dwellings per residential building			
Method	**complexity**	**accuracy**	**cost**
Count all dwelling units in all buildings			
Use existing digital register			
Make estimates from the following information: Size and location • building height, • number of floors • floor space • land-use Building type[37] • detached house, • semi-detached house, • terraced house • multi-story building			
Extrapolate from samples of different building types[37]			
Use statistical data to make estimations of dwellings units per building based on the following information: • living space per resident, • living space per dwelling unit • number of residents in a given area • number of dwellings in a given area			

Tool 20.2: Population per dwelling			
Method	**complexity**	**accuracy**	**cost**
Count all residents in all dwelling units			
• acquire number of dwelling units per building using Tool 20.1 • acquire number of residents per building using Toolkit 19 • distribute equally per building (divide residents by dwelling units)	38	38	38

[37] To identify different building types use surface area covered by the building and the property boundaries or make site visits

[38] The complexity, accuracy and cost depend on the methods used in Tool 20.1 and Toolkit 19

Toolkit 21: Assignment of noise levels to residents in dwellings in multi-occupied buildings.	
Information required	**applicable tool**
Position of dwellings within residential building known (See section 2.44 (ii))	use Tool 21.1
Position of dwellings within residential building not known (See section 2.44 (iii))	use Tool 21.2

Tool 21.1: Position of dwellings within residential building known			
Method	**complexity**	**accuracy**	**cost**
Use noise levels calculated around facades of building to determine levels along each facade of each dwelling unit. Assign highest overall level at any facade of a dwelling to that dwelling as its “most exposed facade” level.			
Use noise levels calculated at grid points around building to determine levels at each facade of each dwelling unit. Assign highest overall level at any facade of a dwelling to that dwelling as its “most exposed facade” level.			

Tool 21.2: Position of dwellings within residential building not known			
Method	**complexity**	**accuracy**	**cost**
Use noise levels calculated around facades of building to determine levels along each facade. Assign highest overall level at any facade of the building to each dwelling within the building as its “most exposed facade” level.			
Use noise levels calculated at grid points around building to determine levels along each facade. Assign highest overall level at any facade of the building to each dwelling within the building as its “most exposed facade” level.			

References

1. European Commission Working Group Assessment of Exposure to Noise (WG-AEN) Position Paper ‘ Good Practice Guide for Strategic noise mapping and the Production of Associated Data on Noise Exposure Version 1.’ 5 December 2003. Available from http://forum.europa.eu.int/Public/irc/env/noisedir/library

2. The Department for Environment, Food and Rural Affairs (Defra), Research project NAWR 93: ‘ WG-AEN’s Good Practice Guide And The Implications For Acoustic Accuracy.’ May 2005. Shortly to be available at http://www.defra.gov.uk/environment/noise/research/index.htm

3. NMPB, (The French national computation method ‘NMPB-Routes-96 (SETRA-CERTU-LCPCCSTB)’, referred to in ‘Arrêté du 5 mai 1995 relatif au bruit des infrastructures routières, Journal Officiel du 10mai 1995, Article 6’ and in the French standard ‘XPS 31-133’. For input data concerning emission, these documents refer to the ‘Guide du bruit des transports terrestres, fascicule prévision des niveaux sonores, CETUR1980’.)

4. CRTN (Calculation of Road Traffic Noise, Department of Transport/Welsh Office HMSO (UK) 1988 (ISBN 0 11 550847 3

5. ISO 1996-2:1987 Acoustics -- Description and measurement of environmental noise -- Part 2: Acquisition of data pertinent to land use.

6. RMVR 1996 (The Netherlands national computation method published in ‘Reken- en MeetvoorschriftRailverkeerslawaai ’96, Ministerie Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 20 November 1996’.).

7. RMVR 2004. "Reken- en Meetvoorschrift Railverkeerslawaai 2004" Ministerie Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer
   Versie: 7 December 2004

8. CRN, Calculation of Railway Noise, Department of Transport, HMSO (UK) 1995 (ISBN 0 11 551754 5)

9. “STAIRRS Final Technical Report", STR40TR181203ERRI, B Hemsworth, European Rail Research Institute, 18 December 2003

10. Harmonoise; Practical Data Collection for the Harmonoise source model: measurement guideline and analysis.
    http://www.imagine-project.org/

11. Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system. Available from http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:31996L0048:EN:HTML

12. DIRECTIVE 2001/16/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 March 2001 on the interoperability of the trans-European conventional rail system. Available from http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_110/l_11020010420en00010027.pdf

13. HNM “Heliport Noise Model” Version 2.2 User’s Guide”, FAA-AEE-94-01, Volpe Center, February 1994. DOT/FAA/EE/94-01, DOT-VNTSC-FAA-94-3, HNM - Heliport Noise Model, V2.2 User's Guide, February 1994. Available from http://www.volpe.dot.gov/acoustics/pubs1.html

14. INM "Integrated Noise Model" Version 6.0 User's Guide", FAA-AEE-99-03, ATAC and Volpe Center, September 1999.
Available from http://www.volpe.dot.gov/acoustics/pubs1.html

15. RNM "Rotorcraft Noise Model" Manual, WR-98-21, Wyle Laboratories, September 1998 (Lucas, M.J., "Rotorcraft Noise Model Manual", Wyle Research Report WR 98-21, September 1998.)

16. Definition, Identification and Preservation of Urban & Rural Quiet Areas. Final report July 2003. Available from http://forum.europa.eu.int/Public/irc/env/noisedir/library

17. The "Valuation of Noise" Position Paper of EC Working Group - Health and Socio-Economic Aspects (WG-HSEA), 21 November 2003. Available from http://forum.europa.eu.int/Public/irc/env/noisedir/library

18. Miljøprojekt nr. 795, 2003 "Hvad koster støj? - værdisætning af vejstøj ved brug af husprismetoden" (Valuation of noise? – A study of the relationship between actual selling prices of detached houses and road traffic noise levels) http://www.mst.dk/

19. Imagine Project. Available from http://www.imagine-project.org/

For further information on environmental noise issues in general please visit the following website: http://forum.europa.eu.int/Public/irc/env/noisedir/library

Appendix 1

MEMBERSHIP OF WG-AEN

Name	Organisation	Country
HINTON, John (chair)	Birmingham City Council	UK
IRMER, Volker (co-chair)	Umweltbundesamt	Germany
ALSINA DONADEU, Ricardo	Ayuntamiento de Barcelona	Spain
BLOOMFIELD, Alan	Greater London Authority	UK
BOURBON, Christine	Institut Bruxellois pour la Gestion de l'Environnement	Belgium
COELHO, J L Bento	Universidade Tècnica de Lisboa - CAPS	Portugal
McMANUS, Brian	Dublin City Council	Ireland
FÜRST, Nathalie	CERTU - Lyon	France
PSYCHAS, Kyriakos	Ministry of Environment	Greece
RASMUSSEN, Søren	COWI - Odense	Denmark
VAN DEN BERG, Martin	VROM – Amsterdam	Netherlands
GERVASIO, Sandro	AISICO	Italy
Observers		
DELCAMPE, David	European Commission DG Environment	EU
BACKMAN, Anna	European Environment Agency	Denmark

Acknowledgements

The members of WG-AEN would like to thank the following for their help and support in developing this document:

The UK's Department for Environment, Food and Rural Affairs (DEFRA) for its continuing help and, in particular for funding the 'Accuracy Study' (Ref.2);

Colleagues from the IMAGINE Project (Ref.19) and in particular, Brian Hemsworth (Project Co-ordinator) and Rick Jones of AEA Technology - Rail (UK);

Douglas Manvell of the B&K Prediction Partnership;

Hans van Leeuwen of DGMR Industry, Traffic and Environment (The Netherlands);

Simon Shilton of Acustica Ltd (UK); and,

Those individuals and Member States who made such helpful comments on Version 1 of this document (Ref.1).

Appendix 2

Introduction to the use of Geographical Information Systems (GIS) in noise mapping

A GIS may be described as a system **of computer software, hardware and data, and** personnel **to manipulate, analyse and present** information **that is geo-referenced (i.e. tied to a** spatial location**):**

- **system** linking software, hardware, data
- **personnel** a thinking explorer who is key to the power of GIS
- **information** data are cross-referenced for visualization or analysis
- **spatial location** data are linked to a geographic location

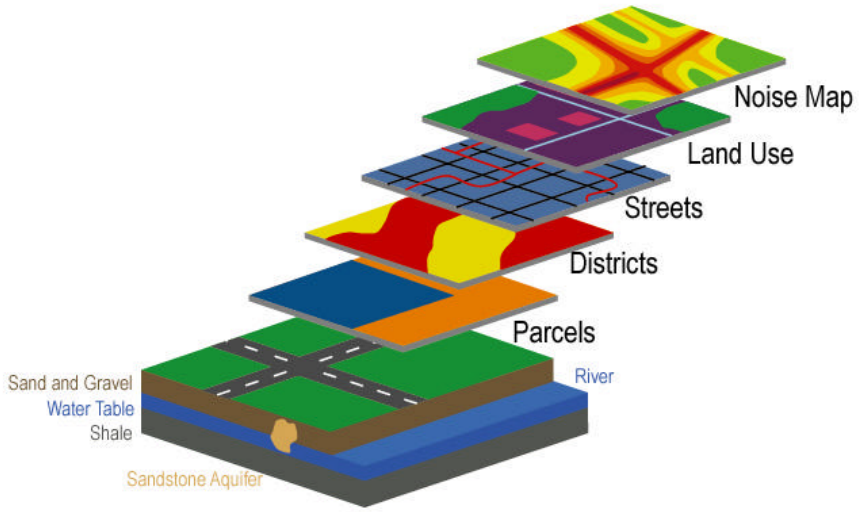


Figure 1 – GIS basic structure

Five basic steps to use GIS in noise mapping applications.
GIS data can help generate acoustic models. However, this data has typically been collected without any consideration of the demands placed by acoustic calculations. Therefore, in many cases, the efficient post-processing of geometry and attribute is essential. Various aspects of this process have to be addressed, including:

- Bringing data into the proper shape (generating building polygons from single vertices, etc.),
- Terrain models: Contour lines vs. ridge models, reconstructing a given topography to define planned situations (for example, fitting a new highway in a landscape),
- Methods of converting 2-D models into 3-D models (interpretation of height attribute information, Laser scan data, use of textual height information, etc.)
- Checking geometric integrity (duplicate objects, source polygons with forward-backward digitising resulting in double emission, etc)
- Merging geometry of differing quality and the inheriting of attributes,
- Simplification of geometry.

When aiming at the exclusive use of commercial GIS tools for data pre-processing limitations of light versions have to be considered.

The exact division of tasks between GIS and calculation software is dependent on how advanced the tools in each software are. Certain tasks can be completed in several ways, with different software types. However, at least one advanced tool in either the GIS or calculation software is advised. In fact, some commercial calculation software does not need work in GIS for fulfilment of the Directive (END), and can even provide end results in GIS-compliant formats.
However initially the most import question that should be asked is 'How are the data outputs to be used and presented'? The answer to this question will dictate the format of the data to be collected, so that it is compatible with either the GIS software and\or the Calculation model. The steps set out below is just one example of an approach.

Table 1 – GIS in noise mapping

... compulsory steps	... selection of issues that may have to be addressed
1. Acquire the data	
Procurement of base data from different sources and integration into the GIS	Site maps, road and railway networks, topographic maps, population data etc. often in many different formats (DXF, grid, proprietary GIS formats etc.) are imported using the data import facilities of the GIS of choice.
Quality assurance, management and maintenance of data in the GIS	Check for currency, accuracy and usability of the data; data management in the GIS database management system.
2. Prepare the scheme	
Identification and assembly of data elements that are of importance for noise mapping	Sources, obstacles, population etc. that are required to map noise are extracted from the larger initial data set(s) acquired at stage 1.

Simplification of data down to the minimum accuracy	Detailed structures will be coupled into larger entities to simplify the calculation scheme. Transform semi-detached houses of similar height into one continuous block. Straighten road curves into a series of connected polylines.
Handling of Possible Duplicate Data	Check geometric integrity (duplicate objects, source polygons with forward-backward digitising resulting in double emission).
Add additional information needed for noise mapping	Building heights, absorption of façades and walls, traffic data, ground effect, etc.
3. Link with noise mapping software to calculate EU noise indicators	
Export prepared data to the noise mapping software	The GIS-Interface of the noise mapping software is used to import all required geometrical and noise source data. Check for the availability of the required interface in the noise mapping software of your choice.
Adaptation of the calculation model and optimisation of the calculation parameters	Check the scheme for compliance with the noise mapping software and make all noise mapping software specific & calculation method specific settings. Make the required efficiency settings to speed up calculation if desired.
Start the noise propagation calculation	
Export calculated results to the GIS	Grids of numeric noise levels, iso-contours, bitmap graphics, façade noise levels etc.
4. Analyse noise data in the GIS	
Cross-correlation of calculated noise levels with other geo-referenced data in the GIS	Maps showing the exceedance of a limit value (limit values are often geo-referenced by their close link to land-use areas), the calculation of noise exposure levels (coupling noise levels to geo-referenced population data), the calculation of the following geo-referenced information asked for in the END: the area, the number of dwellings, the number of people in a certain noise band.
Combining of partial/local noise mapping data to build a larger map	Often, large area noise maps will have to be created by combining the results of smaller noise mapping exercises carried out by different bodies.
5. Presentation of data and information to the EC and to the public	
Presentation of results in the GIS environment	Use the data presentation facilities of the GIS along with aerial photo shots and other geo-referenced information to achieve an enhanced presentation on paper or in a presentation.
Information to the EC	Strategic noise maps and related information is sent to the EC.
Information to the public	The GIS provides a convenient environment to present noise maps either on Internet web pages or on paper/slide presentations.

6. Documenting the process and decisions made	
Metadata capture and management	The GIS provides a cataloguing and metadata management system, which could be used to track data manipulation at each stage of the process. These include: changes to input data, data simplifications, calculation methods, calculation settings, interpolation methods, assumptions and other factors which could influence the accuracy of the results generated.

Coupling GIS and Noise Mapping Software

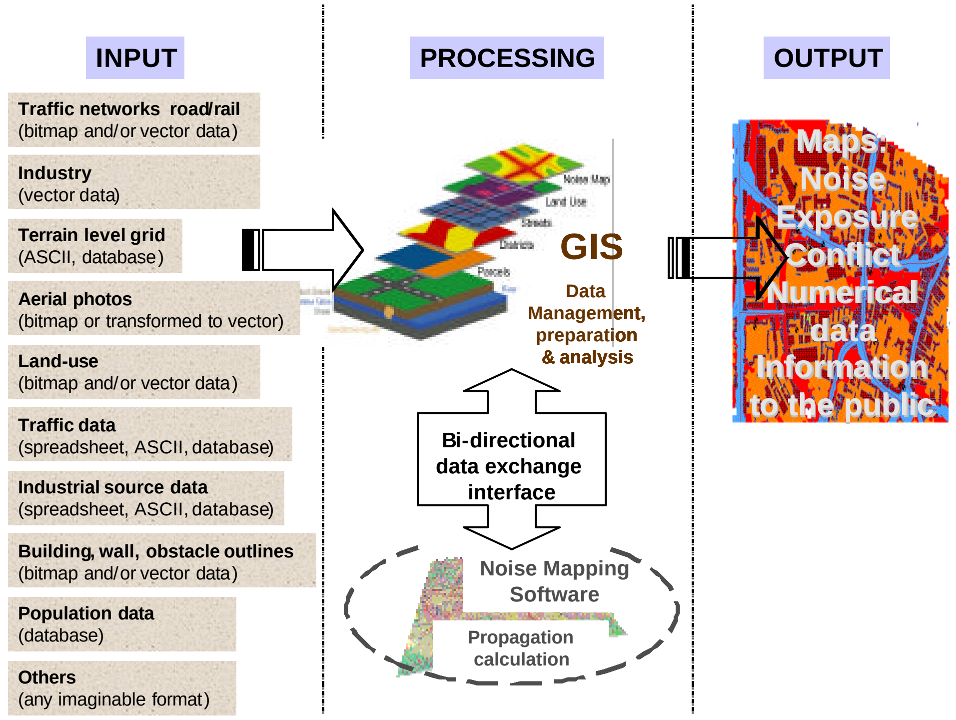


Figure 2 – Coupling GIS and Noise Mapping

The GIS is the central database management engine.

Data are imported into the GIS where the quality is checked and the data is managed, maintained and prepared for export to the noise mapping software.

The GIS and the noise mapping software share a common data exchange interface, i.e. the noise mapping software must be able to read and write data formats compatible with the GIS.

All final maps and all information for the EC and to the public are produced from within the GIS environment, including the generation of web-based services to access and disseminate data over the Internet.

Factors influencing cost

The most important cost factor in noise mapping is the procurement of base data and the digitising of maps.

Final costs depend heavily upon both the type of data already available and the ability and willingness of stakeholders to contribute to the creation of the database.

Bitmap data formats may be useful for illustration but are of limited use in large-scale strategic noise mapping.

The development density, the terrain structure and other elements are important cost factors in the acquisition of geographical data.

The required accuracy of the final results is a major factor in cost estimation.

A cost study commissioned by DG XI D.3 Urban Environment in 1999[39], shows a wide variability in cost estimates for the different E.U. Member Sates (M.S.): the lowest cost is estimated for Germany and the highest cost for Spain, Portugal and Italy. The wide spread of costs can be explained by the obvious difference in experience and availability of suitable data between M.S. and the size difference of the M.S. or their "agglomerations" as defined in Directive 2002/49/EC.

Data sharing

In any type of database, the data should be available in a form that will allow its use in flexible and shared ways. The initial high cost of data-acquisition for its principal use is more easily justified if the data can eventually be shared with other users.

To achieve a high level of data sharing the involvement of analysts and database programmers at an early stage in the process should be ensured.

Data can be made available and stored in many different formats. The most useful formats are flexible and supported by different software applications. If the requirement of shared data use is added, isolated data files and file management programs must be replaced by a Database Management System that manages related data to form databases. Integrity and consistency of data are ensured and redundancy reduced. Databases are accessed by multiple users for different purposes. This concept has been extended over the past years by adding the visual mapping level to enhance information content of geo-referenced data. These software tools are called Geographic Information Systems (GIS).

Strategic noise mapping data must be integrated into GIS in order to be used most effectively. The easier the process of integrating data into GIS, the lower the barrier to use the strategic noise mapping data. Streamlining the process of integrating noise mapping results into GIS ensures its active use and thereby helps to develop action plans and to eventually to implement them.

Both the noise maps and the associated base data must be made available in common digital formats. Both must be geo-referenced in the same co-ordinate system. Note: Directive 2002/49/EC requires neighbouring Member States to co-operate on both strategic noise mapping near borders (Article 7, 4.) and on action plans for border regions (Article 8, 6.) adds another level of complexity, namely the transformation of different national co-ordinate systems.

Features and advantages of using GIS for strategic noise mapping

The centralisation of large amounts of acoustically relevant data from different administrations and authorities acting at different levels of decisional power into one geo-referenced database.

Enhanced control and better understanding of the quality of the data (accuracy, completeness, etc.).

Management of the data in a GIS environment providing a single unified standardised source of data.

The centralised maintenance improves continuity in data management if data- and information-flow are well organised.

The usability of the data is increased because of the geo-referencing of all elements of data within the GIS.

---

[39] **COWI:** Cost Study on Noise Mapping and Action Planning, EC DGXI D.3 Urban Environment, 1999

Scalability is a system feature.
The interconnection of GIS with noise mapping software provides for the fast and accurate assessment of the environmental impact of noise.
The coupling between GIS and noise mapping software implements a planning and information system for noise-triggered decision-making.
The data presentation facilities of a GIS provide options for making information available to the public in a most effective manner.

GIS - Towards a European dimension[40]

The *INSPIRE* Initiative
The general situation on spatial information in Europe is one of fragmentation of datasets and sources, gaps in availability, lack of harmonisation between datasets at different geographical scales and duplication of information collection. These problems make it difficult to identify, access and use data that is available. Fortunately, awareness is growing at national and at EU level about the need for quality geo-referenced information to support understanding of the complexity and interactions between human activities and environmental pressures and impacts.

The need to handle an ever larger number of geo-referenced databases and to link them across borders (in the current context see Directive 2002/49/EC, Article 7, 4.) led the EU to develop the INSPIRE[41] initiative. INSPIRE aims at sharing and linking geo-referenced data throughout EU Member States through "a distributed network of databases linked by common standards and protocols", accessible through interoperable services that will help to produce and publish, find and deliver, and eventually use and understand geographic information over the Internet across European Union and Accession Countries

The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. The target users of INSPIRE include policy-makers, planners and managers at European, national and local level and the citizens and their organisations. Possible services are the visualisation of information layers, overlay of information from different sources, spatial and temporal analysis

Further information on the INSPIRE PROJECT can be found at http://inspire.jrc.it/

[40] All information in this chapter from: INSPIRE Architecture and Standards Position Paper, INSPIRE Architecture and Standards Working Group/JRC-Institute for Environment and Sustainability, ISPRA, 2002-10-03

[41] INSPIRE: INfrastructure for SPatial InfoRmation in Europe http://inspire.jrc.it/

Appendix 3

EC WORKING GROUP ASSESSMENT OF EXPOSURE TO NOISE (WG-AEN).

Proposal for a research project concerning 'Quiet Areas'.

WG –AEN recommends that the project described below may be suitable for funding under the 6th Framework Programme and as such is submitted to the CALM Network for consideration.

Drivers

At present several countries in Europe are attempting to address the issue of quiet areas in regional and local planning. In addition, the EU-Directive 2002/49/EC (the END) requires member states (MS), no later than 18th July 2008, to draw up action plans to protect quiet areas in agglomerations against an increase in noise.
The END leaves it to MS to delimit these areas and merely states that L_{den}, or another appropriate noise indicator, **may** be chosen by MS for this purpose. This, of course, allows MS to adopt different approaches to defining quiet areas in agglomerations. Furthermore, even if a MS chooses to adopt an appropriate noise indicator the END leaves MS to decide upon appropriate limit values.
In respect of quiet areas in the open country the END merely identifies these as areas that are undisturbed by noise from traffic, industry or recreational activities. No actions to protect quiet areas in the open country are required in the first round of action planning (July 2008). However, the Commission is required to assess the need for the protection of these areas in a report it shall present by 18 July 2009.
All this leaves most MS without any guidelines on delimiting quiet areas in either agglomerations or in the open country.

Available data and information

Several desktop studies concerning quiet areas have been carried out recently, including one sponsored by DG-Environment[42], which is based on earlier studies carried out in the US, Norway, Sweden, Ireland, the UK, the Netherlands and New Zealand.

These desktop studies, although extremely useful, have not produced a consistent and definitive set of recommendations for indicators and appropriate limit values for quiet areas.

Scope of proposed research project.

In order to support MS in implementing the END and to provide planning advice on delimiting quiet areas it is proposed that a research study should be carried out.
Recent studies suggest that a person's response to noise in relatively quiet areas is dependant on the activities that they are carrying out, on the levels of background and

[42] Report on the Definition, Identification and Preservation of Urban and Rural Quiet Areas. Final Report July 2003. Symonds Group Ltd.

ambient noise in the area and possibly also on the activities of others using the area for recreational activities.

Therefore, it is recommended that a questionnaire and an associated noise measurement study should be designed for a European wide survey to identify:

1. The most appropriate indicators to determine public response to noise exposure in quiet areas.
2. The most appropriate limit values to delimit quiet areas.
3. Other parameters that are linked to the public's perception of quiet areas (for example: activities being undertaken and the type of environment).
4. Other European definitions that can be linked to the definition of a quiet areas (for example: Natura 2000 areas for open country and public or green areas in agglomerations).

The analyses of the results of the questionnaire may show some significant differences in the public expectations for quiet areas across different MS. However, this questionnaire and the associated noise level study will benefit from a common European approach.

It is foreseen that the questionnaire shall be used to interview at least 1000 members of the public in each of the countries involved in the project whilst these people are visiting relatively quiet areas. Throughout the project a clear divide needs to be maintained between the investigations carried out in, and results obtained for, quiet areas in the open country and those obtained for such areas in agglomerations.

The estimated budget for this research project shall be at least € 500.000.
Positive replies to the suggestion for this research project have already been received from Norway, Germany and Denmark. In addition, interest has been expressed by the UK and Ireland. It is possible that the Netherlands, Finland, Sweden and the Brussels Capital Region might also be interested.

Version dated 15th March 2004.
Compiled by J Hinton and S. Rasmussen on behalf of WG-AEN

Appendix 4

The content of this appendix is based on the so-called 'Accuracy Study' research project. See Reference 2 in the main body of this Position Paper

Please note that information on the relative importance of the different input data required for strategic noise mapping of roads that could help achieve better overall accuracy is provided in Appendix 5

Understanding Sources of Uncertainty in Noise Modelling

Within any modelling system designed to reproduce a real world environment, such as noise mapping, there are four key areas of uncertainty to be considered:

1. estimation of uncertainty in model inputs and parameters (*characterisation of input uncertainties*);

2. estimation of the uncertainty in model outputs resulting from the uncertainty in model inputs and model parameters (*uncertainty propagation*);

3. characterisation of uncertainty associated with different model structures and model formulations (*characterisation of model uncertainty*); and

4. characterisation of the uncertainty in model predictions resulting from uncertainty in the evaluation data (*i.e. if you are validating the calculations against measured levels, how uncertain are your environmental noise measurements?*).

For each of these four areas of potential uncertainty it is possible to discuss some of the practical measures and processes which could be adopted as part of the noise mapping process in order to understand the magnitude of uncertainty in the results.

Input Uncertainty

Characterising input uncertainty would involve a study of each of the various types of data required to construct a finished noise map. These uncertainties arise from various sources including: measurement; management, factoring and assimilating of the actual captured information prior to reporting. To form an understanding for each type of input dataset there would probably need to be liaison with domain specialists such as data providers, owners and managers, in order to seek an understanding of how the uncertainties of the input values are distributed. There would also need to be detailed analysis carried out to quantify the scale and distribution of these uncertainties in the delivered dataset.

MS and noise mapping agents should be aware of the need for characterisation of input uncertainty but it will vary from country to country, dataset to dataset, and each data owner or manager will need to be interviewed regarding this aspect. When known, this information can be used in combination with the results presented within the research project to help understand how these input uncertainties will affect the final result from the model. There are two types of input uncertainty, one is related to raw data and the other is related to data handling.

In the research carried out, it has been assumed that each input dataset has a normal distribution of uncertainty, but the validity of this assumption can only be assessed when more detailed information is known regarding the actual uncertainty distribution in the input datasets.

If a MS wished to better understand these uncertainties, a two-stage approach could be taken:

1. A review across the various technical areas supplying input data in order to find data currently published uncertainty in the source data sets.

2. Where information is not found, then an investigation could be carried out in order to gain an understanding and description of the sources of uncertainty and the factors affecting their magnitude.

Uncertainty Propagation or Sensitivity

Uncertainty Analysis (UA) allows the assessment of model response uncertainties associated with uncertainties in the model inputs. Sensitivity Analysis (SA) studies how the variation in model output can be apportioned to different sources of variations, and how the given model depends upon the information fed into it.

Put simply, if the input data is not absolutely correct, by how many decibels could our calculated noise level vary from the correct result?

The research project focused on assessing the means by which uncertainties, errors or assumptions within the input datasets for noise maps propagate through the calculation tools to produce uncertainties or errors in the decibel results obtained. The recommendations set out within the Toolkits proposed for the GPG v2 refer to the XPS 31-133 Interim Method.

Within this study, some results specific to the use of the UK CRTN method were produced for Defra. It may be appropriate to consider a similar exercise for other national methods to be used within the END if such information is not currently available, e.g. RLS 90 etc.

Model Uncertainties

The characterisation of model uncertainty is a role for the owners and developers of the noise models being used, and as the current first round of END submissions are to use existing calculation methodologies then it follows that the calculation methods are to be used “as is”. Should comparative studies of the national methods be published, or error propagation analysis carried out for each of them, it could help to determine a means by which “equivalence” could be demonstrated for the END.

The second aspect of the model uncertainty is the issue of how the documented standard is transposed from a paper document into a 3D noise calculation tool, and how the tools additional simplifications, efficiency techniques and assumptions introduce further uncertainties into an uncertain methodology in order to create usable real world calculation times.

For this reason, it may be appropriate to discuss some of the aspects of noise mapping tools that may make them suitable for large area agglomeration mapping, and reduce the risk of additional uncertainties being introduced. It is considered to be relevant to the first round of mapping projects to establish:

- What issues are there within the paper standard that could lead to differing interpretation by software developers?
- How have these issues been solved by the current software tools?
- Could a “standard” interpretation be developed?
- How is compliance with the standard tested, if at all, and how could an approach be developed to reduce variance?
- How do the software “efficiency” techniques impact upon the accuracy of the results obtained?

Uncertainty of Evaluation Data

The issues surrounding uncertainties in environmental noise measurements have been researched in detail by Craven & Kerry [43], whose work suggested that for short term measurements you are doing well if repeat measurements are within 5 dB(A) at the same site, for the same source, on different days. Having said that, the basis of the END submissions is long term values of L_{den} and L_{night}, where “long term” generally means “annual average”, or even “several year average” when meteorological effects are to be considered.

Work within the Harmonoise project has carried out long term monitoring exercises and compared them with calculations using the Harmonoise methodology. This work indicates that the uncertainties in the measured levels can be reduced if the measurements span over a year and the meteorological and ground absorption factors are representative of a several year average.

[43] A Good Practice Guide on the Sources and Magnitude of Uncertainty Arising in the Practical Measurement of Environmental Noise. N J Craven, G Kerry, DTI Project: 2.2.1 – National Measurement System Programme for Acoustical Metrology, University of Salford, October 2001 ISBN: 0-9541649-0-3.

Further work is required in this area to extend the approach set out by Craven & Kerry and assess it in the context of long term monitoring. This could initially be carried out by re-analysis of available long-term measurement results, but could be extended to investigate each aspect more thoroughly.

The above four uncertainties are inter-related to each other as in Figure 4.1 shown below. It is therefore important that the different types of uncertainties should be taken into account when evaluating the decibel error in the noise mapping result.

Only with a complete understanding and evaluation of all these areas of uncertainty may the resultant decibel level be stated with certainty. It is considered that offering a number of the GPG v2 Toolkits with a statement of acoustic accuracy will help to develop an understanding of the potential uncertainty introduced by the use of inaccurate input data, and will help to promote further investigations into the various technical aspects affecting the accuracy of the result.

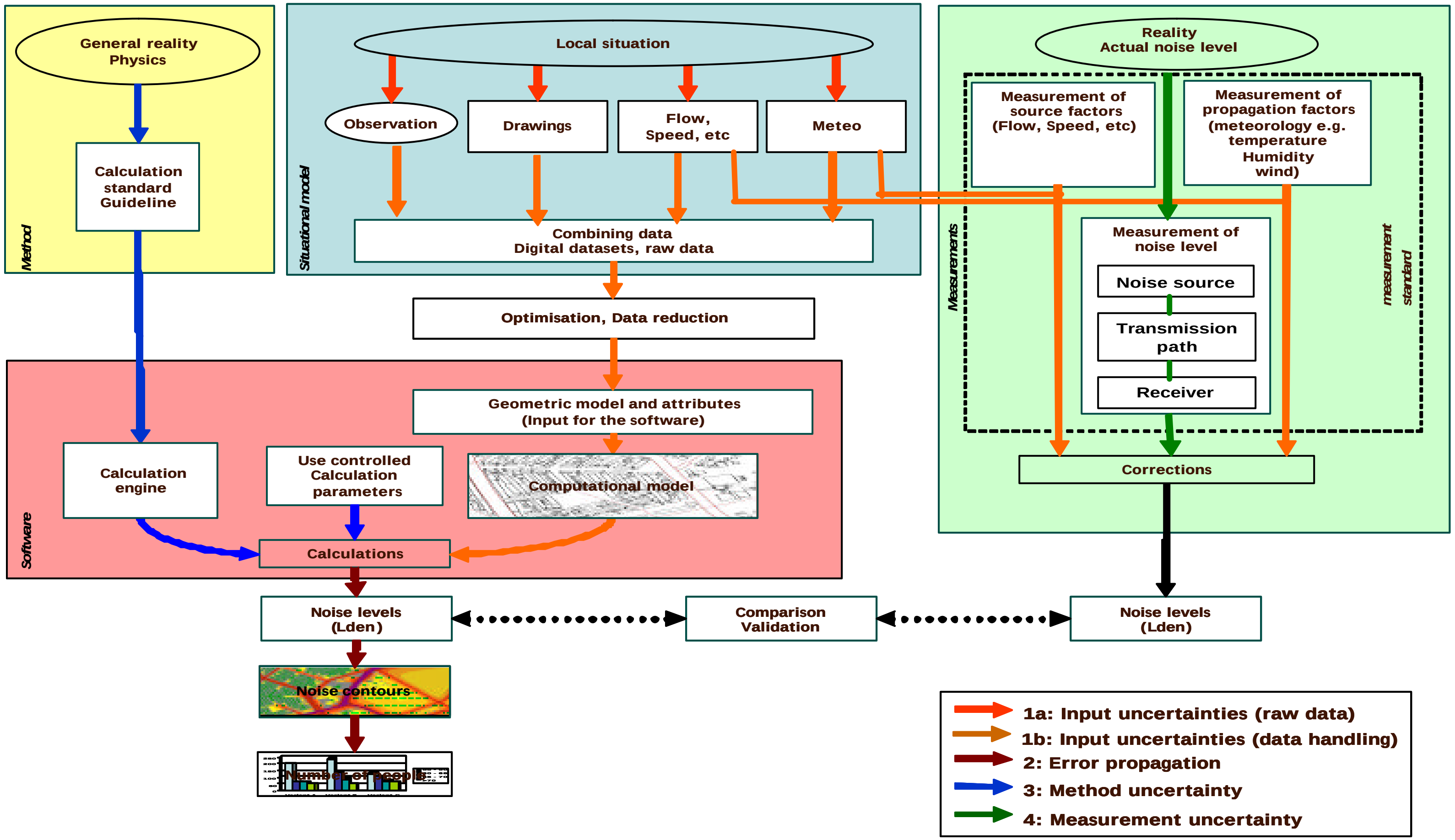


Figure 4.1: How different types of uncertainties are inter-related to each other

Appendix 5

The content of this appendix is taken from the so-called 'Accuracy Study' research project. See Reference 2 in the main body of this Position Paper.

The importance of data for strategic noise mapping (of road traffic noise)

Following on from the work on single and multi-parameter input testing of XPS 31-133 Interim Method, it is not only possible to assign guidance to the selection steps within the GPG Toolkits, but also possible to draw up a proposal for a dataset specification suitable for the purpose of noise mapping in support of developing the END results and subsequent noise action plans. The recommendations are presented in the subsequent sections, each outlining different aspects of the required dataset, or possibly different model objects.

Alongside the data object definitions, data accuracy recommendations are made, where possible. The approach to accuracy constraints is based upon the sensitivity testing carried out within this research project. The concept is to assign a "Group" reference to the supplied dataset, such that the potential error in calculations is understood.

- Group A is aimed to have very detailed input data. This group should be used for detailed calculations, and for validation.
- Group B is aimed to manage uncertainty in the input attributes to within limits which each produce less than a 1 dB error;
- Group C is aimed to manage the input specifications such that potential errors in each element produce less than 2 dB of error;
- Group D is aimed to manage the input specifications such that potential errors in each aspect produce less than 5 dB of error. NOTE: in some cases, for END mapping, use of the guidance within the GPG may result in lower levels of error than using the available data; and
- Group E is assigned when requested limits desired for Groups A, B or C cannot be met with confidence, in this case it is recommended that data quality is improved where possible by new data capture, or by using the guidance within the GPG, in preference to the data available.

It should also be noted that the multi-parameter sensitivity testing carried out has indicated that the compound effect of a number of parameters each in error, will result in a combined error of higher magnitude. For example, managing to contain each input dataset to fit within Group C, less than 2 dB per parameter variation, could lead to an overall calculated level with an uncertainty in the order of 5 dB.

Non-Geometric Aspects

1. Propagation error due to uncertainty in the input parameters in the XPS 31-133 methodology is found to be significant for some input parameters and traffic scenarios. The simulations show that the propagation error in XPS 31-133 is scenario dependent. This is because of the multiple functions used in the method for different traffic conditions and scenarios.

2. Uncertainty in the vehicle speed gives the largest decibel error in the calculated result. In general, the decibel error increases with the input magnitude. Therefore, for high input value, more accurate input data is required.

3. The decibel error due to multiple simultaneous input uncertainties is larger than those with a single input uncertainty. This also means in the case of multiple input uncertainties, the accuracy requirement for each input parameter will be higher than those with a single input uncertainty.

4. Table 5.1 below ranks the sensitivity of the decibel error in the calculated result to the uncertainty of the input parameter to noise emission calculation in a descending order. Two scenarios are presented which correspond to a high noise case (percentage of heavy vehicles greater than 30%) and a low noise case (percentage of heavy vehicles less than 30%).

Table 5.1: Order of merit for input parameters to noise emission calculation

Rank of important	Percentage of heavy vehicle (%HV > 30)	Percentage of heavy vehicle (%HV < 30)
1st	Heavy vehicle velocity (HV)	Light vehicle velocity (LV)
2nd	Heavy vehicle flow (Hq)	Light vehicle flow (Lq)
3rd	Light vehicle velocity (LV)	Heavy vehicle velocity (HV)
4th	Light vehicle flow (Lq)	Heavy vehicle flow (Hq)
5th	Road gradient	Road gradient
6th	Road surface	Road surface

Geometric Aspects

Source height

Due to the fact that the ground near the source is always considered acoustically reflecting, the sensitivity of the ground effect for source height variations is weak. It is of more importance if source height variations lead to varying diffraction effects by screening objects. A shallow cutting has more influence on the noise levels than a low embankment. However, if a barrier is placed along the road, the effects of an embankment increase up to those for a cutting.

Ground surface type
Using hard ground as a default ground type can lead to local inaccuracies of 10 dB(A). For suburban cases with mixed ground, the average error is in the order of 2 dB(A).

The accuracy of calculations can strongly be improved by distinguishing between urban, suburban and rural areas of by the use of polygons with a land use classification. Though extreme local errors may occur like in the case of hard ground by default, 95% of all noise levels will be within +/-1.5 dB(A).

Ground elevation
In hilly terrain, ground elevation variations may lead to diffraction effects and substantial inaccuracies of the ground elevation model will then lead to extreme associated errors in the noise levels.

Barrier height
The effects of inaccuracies in the barrier height have a local impact on the noise levels. Although extreme errors are found in the proximity of the barriers, the noise levels are generally within +/-2 dB(A) when the barrier height can be estimated within 1m.

Building heights
If the number of storeys is known for each building and if the default storey height is fairly representative for the mapping (sub) area, this will lead to a very accurate estimation of the building height. The general accuracy of the noise map is about 1.5 dB(A).

The use of a default building height for building types, for the whole mapping area or for sub areas, requires a good estimation of the average height in order to get sufficient accuracy in the calculated noise level.

Building and barrier absorption coefficients
The effect of reflections from buildings or other vertical surfaces is stronger in dense, urban areas than in suburban regions. The strongest effects are found behind the first row of buildings, where noise levels are relatively low.

Guideline
Table 5.2 on the next two pages sets out the recommendations for the uncertainty values to be used in order to assess the quality of an input dataset for noise mapping purposes, or where a data capture exercise is to be commissioned.

Table 5.2 XPS 31-133 Road Traffic Data Attributes

	Traffic Flow	Group A 0.5-1dB(A)	Group B 0.5-1dB(A)	Group C 1-3dB(A)	Group D 3-5dB(A)	Group E >5dB(A)
Heavy Vehicle Flow (Hq)	Continuous Fluid	20%<	20-40%	40-90%	90-160%	>160%
	Non differentiated Pulsed					
	Pulsed Accelerated					
	Pulsed Decelerated					
Heavy Vehicle Velocity (HV)	Continuous	10%<	10-20%	20-70%	70-130%	>130%
	Non differentiated Pulsed					
	Pulsed Accelerated					
	Pulsed Decelerated	5%<	5-10%	10-30%	30-50%	>70%
Light Vehicle Flow (Lq)	Continuous	20%<	20-45%	45-100%	100-200%	>200%
	Non differentiated Pulsed					
	Pulsed Accelerated					
	Pulsed Decelerated					
Light Vehicle Velocity (LV)	Continuous	10%<	10-20%	20-65%	65-120%	>120%
	Non differentiated Pulsed					
	Pulsed Accelerated					
	Pulsed Decelerated	5%<	5-10%	10-40%	40-95%	>95%

Table 5.2 XPS 31-133 Road Traffic Data Attributes (continued)

	Factor	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
Source	Gradient Type (flat= >+2% - <-2%)	No error, sections <50m	No error, sections <100m	No info (up or down), sections <200m	No info (up or down)	No info (up or down)
	Traffic Flow Type	No error	Within 1 class	Within 1 class (continuous)	No info (continuous)	No info (continuous)
	Surface Type	No error, sections <50m	No error, use classes	= 1 class away	= 2 classes away	No info (dense asphalt)
	Road centreline (Vertical)	<0.5m	>0.5m - <1.0m	>1.0m - <2.0m	>2.0m - <5.0m	>5.0m
	Road centreline (Horizontal)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m

Table 5.2 XPS 31-133 Road Traffic Data Attributes (continued)

	Factor	Group A	Group B	Group C	Group D	Group E
Ground Model	Ground height, contours, TINs etc (Vertical)	<0.5m	>0.5m - <1.2m	>1.2m - <2.5m	>2.5m - <5.0m	>5.0m
	Ground height, contours, TINs etc (Horizontal)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m
	Profile edges (Vertical)	<0.5m	>0.5m - <1.2m	>1.2m - <2.5m	>2.5m - <5.0m	>5.0m
	Profile edges (Horizontal)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m
	Equal height contour spacing (Vertical)	<1.0m	>1.0m – <3.0m	>3.0m - <8.0m	>8.0m - <15m	>15m
Buildings	Buildings (Vertical)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m
	Buildings (Horizontal)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m
	Building Minimum Size (m^2)	<5m^2	>5m^2 - <15m^2	>15m^2 - <30m^2	>30m^2 - <50m^2	>50m^2
	Absorption coefficient	No error	Use absorption classes	Use absorption classes	No info (reflective)	No info (reflective)
Barriers	Barriers (Vertical re road surface)	<0.5m	>0.5m - <1.0m	>1.0m - <2.0m	>2.0m - <5.0m	>5.0m
	Barriers (Horizontal, re road surface)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m
	Barrier Minimum Height (m)	<1.0m	>0.5m - <1.0m	>1.0m - <2.0m	>2.0m - <5.0m	>5.0m
	Barrier Minimum Length (m)	<10m	>10m - <25m	>25m - <40m	>40m - <100m	>100m
	Absorption coefficient	No error	Use absorption classes	Use absorption classes	No info (reflective)	No info (reflective)
Ground Cover	Hard / Intermediate / Soft ground ratio	<5%	>5% - <10%	>10% - <25%	>25% - <50%	>50%
	Ground Type minimum size (m^2)	<5m^2	>5m^2 - <15m^2	>15m^2 - <30m^2	>30m^2 - <50m^2	>50m^2

Notes:

1. The above uncertainty ranges are based upon the "worst case" identified for each aspect from the single parameter sensitivity test,
2. The heavy vehicle speed has become the key factor due to the uncertainty behaviour for flat roads, the up or down cases give almost double the ranges stated above,
3. The "no info" entries have a suggested default value, which minimises the potential error.

Table 5.3 shows that in the case of multiple input uncertainties, the recommendations for the uncertainty values to be used in order to assess the quality of an input dataset for noise mapping purposes are higher than the case of single input uncertainty.

Table 5.3: XPS 31-133 – uncertainties in the vehicle velocity and traffic flow for decibel errors of 1 and 5 dB(A) in the calculated result for different road gradients. Pulsed decelerated traffic flow model.

	High Noise Case			Low Noise Case		
	Up	Down	Flat	Up	Down	Flat
Hq, Lq, Hv, Lv ±1dB(A) error	±10%	±20%	±10%	±10%	±10%	±10%
Hq, Lq, Hv, Lv ±5dB(A) error	±80%	±90%	±50%	±90%	±70%	±60%

Notes on manipulating input data for noise mapping purposes

The input datasets presented at the commencement of a noise mapping project not only need to be analysed in order to determine their quality, but also to enable them to best serve the purpose of noise mapping calculations. Frequently, input datasets are presented at a level of precision which is quite unnecessarily detailed for noise mapping calculations. An example could be the frequency with which points along equal height contours, or road centrelines are specified.

The values above may act as a guide to the extent to which incoming datasets may be simplified, before being passed into the noise calculation software, without this simplification detracting from the overall quality objectives of the project.

In addition to the above guidance, there are further points raised below which it is appropriate to consider whilst creating a noise calculation model from received information.

Road Segmentation

Road segmentation is normally handled on an automatic basis by advanced noise software tools as the roads are "draped" onto the underlying ground elevation model. In certain situations it is possible this may not occur, such as when there is no ground elevation model available, or in areas of very level ground. It is therefore recommended that the road centreline dataset is pre-segmented such that even in the absence of sub-segmentation by the software, it complies with the segmentation rules set out within the calculation standard.

In this example we will use CRTN, which states that segmentation should occur in accordance with a 2 dB change rule, i.e. the variation in potential emission level should be restrained to less than a 2 dB change within one segment. On this basis, the road centrelines should be segmented in line with the following rules:

- Max change between segments 2dB
    - Max change in gradient 6%
    - Max gradient 30% limited
    - Horizontal deviation: Centreline deviates from actual centreline by no more than 1.0m horizontally
    - Vertical deviation: lane centreline deviates from actual by no more than 0.5m vertically
    - Change in traffic flow by no more than 10%
    - Change in %HGV by no more than 40%
    - Change in road surface type
    - Change in texture depth by no more than 0.4mm
    - Traffic speed changes by no more than 10%, or changes default road type class
    - Road carriageway width changes by no more than 1.0m
    - When road changes from two way to one way

- Split carriageways should be modelled with two centrelines in the following situations:
    - More than 5.0m separation between lanes
    - More than 1.0m height difference between outside edges of lanes
    - When there are 4 lanes in one or both directions
    - Possibly when there are 3 lanes in one or both directions

Barrier Segmentation

- Barrier segmentation should occur:
  - When height of top of barrier changes by more than 0.5m (relatively to the road surface)
  - When horizontal location differs by more than 1.0m horizontally – try to link to road centreline segmentation when they are parallel

NOTE: There is a special case for roadside barriers where they are likely to be the most significant screening effect from a road section. Here the desire is to link the segmentation to that of the roads, as mentioned above. It is also desirable to limit the “relative” vertical and horizontal uncertainties, between the road centreline and the barrier, to values below those shown above. Where the barrier and road centreline locations and height datasets come from independent sources, the potential uncertainty will be increased, and the potential for error greater.

Ground Terrain Modelling

The ground terrain profile will need to be represented using two forms of objects to provide compatibility with the noise mapping software tools, and to help provide a dataset that is fit for purpose and optimised for noise calculations.

- Equal Height Contours. *(See Table 8.6.2 of Ref.2 provided on Page 93)*
- Ground Contour Profiles

These are lines, or polylines, which vary in height along their length. They are used to define ground model elements such as:

- Slope edges
- Embankment top and bottom
- Earth bund top and bottom
- Escarpment edges
- Cuttings

- The vertical accuracy of the points along these lines should follow the recommendation in Table 8.6.2. *(See Table 8.6.2 of Ref.2 provided on page 94)*
- Ground Contour Profiles

Building Height Information

Within urban areas where building density is high, the two most important potential noise barriers considered by the calculation method will most likely be the building nearest to the source, and the building nearest to the grid receptor, within the propagation path.

In residential and suburban areas the use of a default building height of 8m, as is common for city noise maps, will lead to only a small potential error in calculated noise levels. However, in city centre locations, or areas with a large percentage of buildings over two storeys high the use of default building heights is likely to introduce significant errors. When using certain existing national calculation methods, which do not provide the option to calculate noise levels on the quiet façade, the use of genuine building heights within areas of high rise development, may lead to calculated noise levels much less accurate than when using an 8m default building height, as they may become unrealistically low.

In rural areas the major screening barriers within the calculation are more likely to be earth embankments or noise barriers, than high-rise buildings. In this case the likelihood of error being introduced by using default building heights in rural locations will be lower than in city locations.

For these reasons it is recommended that real building heights are used within city or urban locations, if available, whilst default building heights could be more appropriate for calculations in rural areas.

Data Accuracy Constraints across Data Corridor

Means of assessing the width of the data corridor, or the agglomeration buffer zone are presented in the WG-AEN GPG Toolkit 16[44]. To compliment this existing advice it is considered appropriate to discuss the requirement for data accuracy across the data corridor.

As the potential accuracy of the calculation method to be used generally decreases with increasing distance from the source, the specified accuracy of model input data should be highest near to the source, and may be acceptable at a lower level further away from the source. The recommended aim is to achieve Group B accuracy within close proximity to the road and rail emission lines, possibly the first 50m either side, with Group C accuracy constraints being acceptable out to 600m, and possibly Group D level accuracy out to longer distances in the buffer areas.

Modelling of Acoustic Ground Type

The default ground type for the dataset should be acoustically hard, with areas of intermediate and soft ground defined as a “closed polygon” in GIS terminology. Where possible these polygons should be concatenated to produce a simplified dataset containing a smaller number of large soft ground areas.

[44] This toolkit was in Version 1 of the GPG but has been removed in this Position Paper.

Analysis of noise mapping input data

It is accepted and understood that the input data required for wide area, large scale, noise mapping is not universally available across MS. For this reason there is set out below an indicative process by which the noise mapping data could be selected:

- Scoping study analyses data, and gaps in data
  - Assess the uncertainty of each input data set
    - This report offers guidance on some aspects
    - GPG v2 offers guidance of absolute accuracy of some aspects
  - Fill in blanks with GPG
    - GPG v2 to provide absolute accuracy assessment within each Toolkit
    - The dB implications of the decisions may be understood
  - Commission data capture exercise
    - Limited budgets – where will expenditure provide best improvement in results?
    - Limited time – which parameter should we investigate
    - Limited techniques – should new techniques be developed for key aspects?

Summary of Recommendations

The focus on controlling the uncertainty in the vertical height of barriers near to the sources is inline with the advice presented above in the sensitivity tests carried out on XPS 31-133.

To summarise the preceding section it can be considered that with regard to XPS 31-133:

- Calculated noise levels within the 300m validation range are generally within 1dB of measured levels, given high quality input data, such as that which results from observed monitoring and simultaneous data capture;
- Out to 600m this calculation error is likely to increase to around 3dB;
- The potential error out to 2 – 3km may well be up to 10dB, or possibly more;
- Management of the uncertainty in vertical, Z, attributes on model information is much more important than the exact horizontal location;
- As the potential accuracy of the calculation method decreases with increasing distance from the source, the specified accuracy of model input data should be highest near to the source, and may be acceptable at a lower level further away from the source;
- The default ground type for the dataset should be acoustically hard, with areas of soft ground defined as closed polygon; and
- Due to the compound nature of uncertainty, the total uncertainty of the result will be higher than the uncertainty of the individual input dataset

Conclusions

Results from research into error propagation through the XPS 31-133 calculation method have been used to help drawing up an interpretation of the END in the context of data requirements, and to present the results in a series of equal noise error bands to help illustrate the order of merit of the datasets, and the potential for resultant error connected with uncertainty in each.

These tables can be used to help in equalising effort across the various input datasets in an effort to maximise value and minimise error. It also needs to be considered that the results of the multi-parameter testing indicated that even if each individual dataset uncertainty was constrained within an error band of say 3 dB, the total resultant uncertainty of the final result is most likely to be in the next uncertainty band above, in this case 5 dB.

Finally, the research suggests that the level of error within the calculated result can be significant in the context of the 5 dB bands of results required for the EU END noise mapping in 2007. The level of accuracy required for some input datasets may well challenge the best information currently available across the EU, and should be seen as an indication of how much data capture and management organisations need to work proactively with the acoustics community if the results in 2012 are to achieve a higher degree of accuracy.

Appendix 6

Impending Dates and Deadlines Relating to the Implementation of the END

Deadlines	Obligations
18 January 2004	Art. 10-1: EC report to EP and Council on noise sources The Commission must submit to the European Parliament and the Council a report containing a review of existing Community measures relating to sources of environmental noise
18 July 2004	Art. 14: transposition Member States must bring into force laws, regulations, and administrative provisions necessary to comply with the END.
30 June 2005	Art. 7-1: report to EC on areas covered by 1st noise maps & action plans Member States must inform the Commission of agglomerations with more than 250 000 inhabitants, major roads which have more than six million vehicle passages per year, major railways which have more than 60 000 train passages per year and major airports within their territories.
18 July 2005	Art. 4: report to EC on competent authorities designated by MS Member States must make available to the Commission and the public information on bodies and authorities responsible for strategic noise maps, action plans and related data collection. Art. 5-4: report to EC on limit values Member States must communicate to the Commission information on any relevant limit values (in force or under preparation) of noise emitted by road traffic, rail traffic, air traffic around airports and industrial activity sites as well as explanation about their implementation.
18 July 2006	Art. 1-2: EC legislative proposals to EP and Council on noise sources The Commission shall submit to the European Parliament and the Council appropriate legislative proposals on noise reduction of main sources of environmental noise (road, rail, aircraft etc.).
30 June 2007	Art. 7-1: 1st round of noise maps (*) Member States must ensure that strategic noise maps showing the situation in the preceding calendar year have been made and, where relevant, approved by the competent authorities, for all agglomerations with more than 250 000 inhabitants and for all major roads which have more than six million vehicle passages per year, major railways which have more than 60 000 train passages per year and major airports within their territories.
30 December 2007 (Then every 5 years)	Art. 10-2: report to EC on 1st noise maps Member States must ensure that information from strategic noise maps as referred in Annex VI of the END are sent to the Commission.
18 July 2008	Art. 8-1: 1st round of action plans (*) Member States must ensure that the competent authorities have drawn up action plans for (a) places near the major roads which have more than six million vehicle passages a year, major railways which have more than 60 000 train passages per year and major airports; (b) agglomerations with more than 250 000 inhabitants.
31 December 2008	Art. 7-2: report to EC on areas covered by the END Member States must inform the Commission of all agglomerations, major roads, major railways and major airports falling under the

	scope of the END.
18 January 2009 (then every 5 years)	Art. 10-2: report to EC on 1st round of action plans Member States must ensure that the information from summaries of action plans as referred in Annex VI are sent to the Commission.
18 July 2009 (Then every 5 years)	Art. 10-4 and 11: EC report to EP and Council on implementation of END The Commission must submit to the European Parliament and the Council a report on implementation of the END, summarizing reported data on strategic noise maps and action plans, assessing the need for further Community actions and proposing if appropriate further Community implementing strategies and measures
30 June 2012 (Then every 5 years)	Art. 7-2: 2nd round of noise maps (*) Member States must ensure strategic noise maps showing the situation in the preceding calendar year have been made and, where relevant, approved by the competent authorities for all agglomerations and for all major roads and major railways within their territories.
18 July 2013	Art. 8-2: 2nd round of action plans (*) Member States must ensure that competent authorities have drawn up action plans for all agglomerations and for all major roads and major railways within their territories.

(*) In compliance with Articles 7-5 and 8-5 strategic noise maps and action plans must be reviewed and if necessary revised every 5 years

Appendix 7

Provisions extracted from the END that are particularly relevant to noise mapping

1) Objectives of strategic noise mapping

Article 1: objectives

(…) the following actions shall be implemented progressively:

(a) the determination of exposure to environmental noise, through noise mapping, by methods of assessment common to the Member States;

(b) ensuring that information on environmental noise and its effects is made available to the public;

(c) adoption of action plans by Member States, based upon noise-mapping results, with a view to preventing and reducing environmental noise where necessary and particularly where exposure levels can induce harmful effects on human health and to preserving environmental noise quality where it is good.

Article 8: action plans

1. (…) The measures within the plans are at the discretion of the competent authorities, but should (…) apply in particular to the most important areas as established by strategic noise mapping. (…)

Article 9: information to the public

1. Member States shall ensure that the strategic noise maps (…) are made available and disseminated to the public in accordance with the relevant Community legislation (…) and in conformity with Annex IV (…) including by means of available information technologies.

2. This information shall be clear, comprehensible and accessible. A summary setting out the most important points shall be provided.

Annex IV: Minimum requirements for strategic noise mapping

4. Strategic noise mapping will be used for the following purposes:
- the provision of the data to be sent to the Commission (…),
- a source of information for citizens (…),
- a basis for action plans (…).

Each of those applications requires a different type of strategic noise map.

2) Presentation and content of strategic noise maps

Annex IV: Minimum requirements for strategic noise mapping

2. Strategic noise maps may be presented to the public as:
- graphical plots,
- numerical data in tables,
- numerical data in electronic form.

5. Minimum requirements for the strategic noise maps concerning the data to be sent to the Commission are set out in paragraphs 1.5, 1.6, 2.5, 2.6 and 2.7 of Annex VI.

6. For the purpose of informing the citizens (…) and the development of action plans (…), additional and more detailed information must be given, such as:
- a graphical presentation,
- maps disclosing the exceeding of a limit value,
- difference maps, in which the existing situation is compared with various possible future situations,

(…)

The Member States may lay down rules on the types and formats of these noise maps.

7. Strategic noise maps for local or national application must be made for an assessment height of 4 metres and the 5 dB ranges of L_{den} and L_{night} as defined in Annex VI.

3) Areas and noise sources to be mapped

Recital (10)

Strategic noise mapping should be imposed in certain areas of interest as it can capture the data needed to provide a representation of the noise levels perceived within that area.

Article 2: scope

1. This Directive shall apply to environmental noise to which humans are exposed in particular in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals and other noise-sensitive buildings and areas.

2. This Directive shall not apply to noise that is caused by the exposed person himself, noise from domestic activities, noise created by neighbours, noise at work places or noise inside means of transport or due to military activities in military areas.

Article 7: strategic noise mapping

1. Member States shall ensure that no later than 30 June 2007 strategic noise maps showing the situation in the preceding calendar year have been made (…) by the competent authorities, for all agglomerations with more than 250,000 inhabitants and for all major roads which have more than 6 million vehicle passages a year, major railways which have more than 60,000 train passages per year and major airports within their territories.

2. Member States shall adopt the measures necessary to ensure that no later than 30 June 2012, and thereafter every 5 years, strategic noise maps showing the situation in the preceding calendar year have been made (…) by the competent authorities for all agglomerations and for all major roads and major railways within their territories.

3. The strategic noise maps shall satisfy the minimum requirements laid down in Annex IV.

Annex IV: Minimum requirements for strategic noise mapping

3. Strategic noise maps for agglomerations shall put the emphasis on the noise emitted by:
- road traffic,
- rail traffic,
- airports,
- industrial activity sites, including ports.

8. For agglomerations separate strategic noise maps must be made for road-traffic noise, rail-traffic noise, aircraft noise and industrial noise. Maps for other sources may be added.

4) Noise indicators

Recital (7)

In accordance with the principle of subsidiarity (…), the Treaty objectives of achieving a high level of protection of the environment and of health will be better reached by complementing the action of Member States by a Community action achieving a common understanding of the noise problem. Data about environmental noise levels should therefore be collected, collated or reported in accordance with comparable criteria. This implies the use of harmonized indicators and evaluation methods, as well as criteria for alignment of noise-mapping. Such criteria and methods can best be established by the Community.

Recital (9)

The selected common noise indicators are L_{den}, to assess annoyance, and L_{night}, to assess sleep disturbance. It is also useful to allow Member States to use supplementary indicators in order to monitor or control special noise situations.

Article 5: noise indicators and their application

1. Member States shall apply the noise indicators L_{den} and L_{night} as referred in Annex I for the preparation and revision of strategic noise mapping in accordance with Article 7.

Until the use of common assessment methods for the determination of L_{den} and L_{night} is made obligatory ([45]), existing national noise indicators and related data may be used by Member States for this purpose and should be converted into the indicators mentioned above. These data must not be more than three years old.

2. Member States may use supplementary noise indicators for special cases such as those listed in Annex I(3).

Annex I

[45] To that end, the Commission sponsored HARMONOISE and IMAGINE projects, see www.imagine-project.org

1. Definition of the day-evening-night indicator L_{den}

(…) $$L_{den} = 10 \lg \frac{1}{24}\left(12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening}+5}{10}} + 8 * 10^{\frac{L_{night}+10}{10}}\right)$$

in which:

- L_{day} is the A-weighted long term average sound level as defined by 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 by 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 by ISO 1996-2: 1987, determined over all the night periods of a year;

in which:

- the day is 12 hours, the evening 4 hours and the night 8 hours. The Member States may shorten the evening period by 1 or 2 hours and lengthen the day and/or the night period accordingly provided that this choice is the same for all the sources (…)

- the start of the day (…) shall be chosen by the Member State (that choice shall be the same for noise from all sources); the default values are 7.00 to 19.00, 19.00 to 23.00 and 23.00 to 07.00 local time

- a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances;

(…)

- the incident sound is considered, which means that no account is taken of the sound that is reflected at the façade of the dwelling under consideration (…)

The height of the L_{den} assessment point depends on the application:

- in the case of computation for the purpose of strategic noise mapping (…) the assessment point must be 4 -/+ 0,2 metres above the ground and at the most exposed façade (…)

- in the case of measurement for the purpose of strategic noise mapping (…), other heights may be chosen, but they must never be less than 1,5 metres above the ground, and results should be corrected in accordance with an equivalent height of 4 metres

(…)

2. Definition of the night-time noise indicator L_{night}

The night-time noise indicator L_{night} is the A-weighted long term average sound level as defined by ISO 1996-2: 1987, determined over all the night periods of a year;

In which:

- the night is 8 hours as defined in paragraph 1 [of Annex I],

- a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, as defined in paragraph 1 [of Annex I];

- the incident sound is considered, as laid down in paragraph 1 [of Annex I];

- the assessment point is the same as for L_{den}.

(…)

5) Assessment methods

Recital (7)

In accordance with the principle of subsidiarity (…), the Treaty objectives of achieving a high level of protection of the environment and of health will be better reached by complementing the action of Member States by a Community action achieving a common understanding of the noise problem. Data about environmental noise levels should therefore be collected, collated or reported in accordance with comparable criteria. This implies the use of harmonized indicators and evaluation methods, as well as criteria for alignment of noise-mapping. Such criteria and methods can best be established by the Community.

Recital (8)
It is also necessary to establish common assessment methods for 'environmental noise' and a definition for 'limit values', in terms of harmonized indicators for the determination of noise levels. The concrete figures of any limit values are to be determined by the Member States, taking into account, *inter alia*, the need to apply the principle of prevention in order to preserve quiet areas in agglomerations.

Recital (15)
The technical provisions governing the assessment methods should be supplemented and adapted as necessary to technical and scientific progress and to progress in European standardization.

Article 6: assessment methods

1. The values of L_{den} and L_{night} shall be determined by means of the assessment methods defined in Annex II.

2. Common assessment methods for the determination of L_{den} and L_{night} shall be established by the Commission (…) through a revision of Annex II ([46]). Until these methods are adopted, Member States may use assessment methods adapted in accordance with Annex II and based upon the methods laid down in their own legislation. In such case, they must demonstrate that those methods give equivalent results to the results obtained with the methods set out in paragraph 2.2 of Annex II.

3. Harmful effects may be assessed by means of the dose-effect relations referred to in Annex III [46].

Annex II

1. Introduction

The values of L_{den} and L_{night} can be determined either by computation or by measurement (at the assessment position). For prediction only computation is applicable. Provisional computation and measurement methods are set out in paragraphs 2 and 3.

2. Interim computation methods for L_{den} and L_{night}

2.1. Adaptation of existing national computation methods

If a Member State has national methods for the determination of long-term indicators those methods may be applied, provided that they are adapted to the definitions of the indicators set out in Annex I. For most national methods this implies the introduction of the evening as a separate period and the introduction of the average over one year. Some existing methods will also have to be adapted as regards the exclusion of the façade reflection, the incorporation of the night and/or the assessment position. The establishment of the average over a year requires special attention. Variations in emission and transmission can contribute to fluctuations over a year.

2.2. Recommended interim methods

For Member States that have no national computation methods or Member States that wish to change computation method, the following methods are recommended:

For industrial noise:
ISO 9613-2, Part 2 (…)
ISO 8297:1994 (…)
EN ISO 3744: 1995 (…)
EN ISO 3746: 1995 (…)

For aircraft noise:
ECAC.CEAC Doc. 29, 1997 (…)
Segmentation technique referred to in section 7.5 of ECAC.CEAC Doc. 29

For road traffic noise:
NMPB-Routes-96 (…)
XP S 31-133 (…)
For input data concerning emission, (…) Guide du bruit des transports terrestres, fascicule de prévision des niveaux sonores, CETUR 1980

For railway noise:
RMR 96, (…) 20 November 1996

[46] See position papers made by Commission working groups on dose-response relationships between transportation noise and annoyance as well as on does-effect relationships for night-time noise which are available at http://europa.eu.int/comm/environment/noise

Those methods must be adapted to the definitions of L_{den} and L_{night}. (…) the Commission will publish guidelines ([47]) (…) on the revised methods and provide emission data for aircraft noise, road traffic noise and railway noise on the basis of existing data.

3. Interim measurement methods for L_{den} and L_{night}

If a Member State wishes to use its own official measurements method, that method shall be adapted in accordance with the definitions of the indicators set out in Annex I and in accordance with the principles governing long-term average measurements stated in ISO 1996-2: 1987 and ISO 1996: 1982.

If a Member State has no measurement method or if it prefers to apply another method, a method may be defined on the basis of the definition of the indicator and the principles stated in ISO 1996-2: 1987 and ISO 1996-1: 1982.

Measurement data in front of a façade or another reflecting element must be corrected to exclude the reflected contribution of this façade or element (as a general rule, this implies a 3 dB correction in case of measurement).

6) Data reporting and collection

Recital (13)
Data collection and the consolidation of suitable Community-wide reports are required as a basis for future Community policy and for further information of the public.

Article 10: collection of data (…)

2. The Member States shall ensure that the information from strategic noise maps (…) as referred in Annex VI are sent to the Commission within 6 months of the dates laid down in Articles 7 and 8 respectively.

Annex VI: data to be sent to the Commission

1. For agglomerations

1.5. The estimated number of people (…) living in dwellings that are exposed to each of the following bands of values of L_{den} in dB 4 metres above the ground on the most exposed façade: 55-59, 60-64, 65-69, 70-74, > 75 separately for road, rail and air traffic and from industrial sources (…)

In addition it should be stated, where appropriate and where such information is available, how many persons in the above categories live in dwellings that have:
- special insulation against the noise in question (…),
- a quiet façade (…).

An indications should also be given on how major roads, major railways and major airports (…) contribute to the above.

1.6. The estimated total number of people (…) living in dwellings that are exposed to each of the following bands of values of L_{night} in dB 4 metres above the ground on the most exposed façade: 50-54, 55-59, 60-64, 65-69, > 70 separately for road, rail and air traffic and from industrial sources (…)

In addition it should be stated, where appropriate and where such information is available, how many persons in the above categories live in dwellings that have:
- special insulation against the noise in question (…),
- a quiet façade (…).

It must also be indicated how major roads, major railways and major airports (…) contribute to the above.

2. For major roads, major railways ad major airports

2.5. The estimated number of people (…) living outside agglomerations in dwellings that are exposed to each of the following bands of values of L_{den} in dB 4 metres above the ground on the most exposed façade: 55-59, 60-64, 65-69, 70-74, > 75.

In addition it should be stated, where appropriate and where such information is available, how many persons in the above categories live in dw ellings that have:
- special insulation against the noise in question (…),
- a quiet façade (…).

2.6. The estimated number of people (…) living outside agglomerations in dwellings that are exposed to each of the following bands of values of L_{night} in dB 4 metres above the ground on the most exposed façade: 50-54, 55-59, 60-64, 65-69, > 70. (…)

[47] See Commission recommendations C(2003) 2607: http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_212/l_21220030822en00490064.pdf

In addition it should be stated, where appropriate and where such information is available, how many persons in the above categories live in dwellings that have:
- special insulation against the noise in question (…),
- a quiet façade (…).

2.7. The total area (in km^2) exposed to values of L_{den} higher than 55, 65 and 75 dB respectively. The total number of dwellings (…) and the estimated total number of people (…) living in each of these areas must also be given. Those figures must include agglomerations.

The 55 and 65 dB contours must also be shown on one or more maps that give information on the location of villages, towns and agglomerations within those contours.

7) Definitions (Article 3)

(a) 'environmental noise' shall mean unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity (…)

(d) 'noise indicator' shall mean a physical scale for the description of environmental noise, which has a relationship with a harmful effect

(e) 'assessment' shall mean any method used to calculate, predict, estimate or measure the value of a noise indicator or the related harmful effects

(j) 'dose-effect relation' shall mean the relationship between the value of a noise indicator and a harmful effect

(k) 'agglomeration' shall mean part of the 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

(l) 'quiet area in an agglomeration' shall mean an area, delimited by the competent authority, for instance which is exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member States, from any noise source

(m) 'quiet area in open country' shall mean an area, delimited by the competent authority, that is undisturbed by noise from traffic, industry, or recreational activities

(n) 'major road' shall mean a regional or international road, designated by the Member State, which has more than 3 million vehicle passages a year

(o) 'major railway' shall mean a railway, designated by the Member State, which has more than 30,000 train passages per year

(p) 'major airport' shall mean a civil airport, designated by the Member State which has more than 50,000 movements per year (a movement being a take-off or a landing), excluding purely for training purposes on light aircrafts

(r) 'strategic noise map' shall mean a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area

(s) 'limit value' shall mean a value of L_{den} or L_{night}, and where appropriate L_{day} and $L_{evening}$, as determined by the Member State, the exceeding of which causes competent authorities to consider or enforce mitigation measures (…)