CEDR Transnational Road Research Programme

Call 2012: Noise: Integrating strategic noise management into the operation and maintenance of national road networks

CEDR
Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

funded by Belgium/Flanders, Germany, Ireland, Norway, Sweden, United Kingdom

DISTANCE

Data requirements for future noise mapping and action planning

Deliverable 2.1, 06. 2015

Distance **Developing Innovative Solutions for TrAffic Noise Control in Europe**

Partners:

BRRC (Belgian Road Research Laboratory) [Belgium]

TRL (Transport Research Laboratory) [UK]

SINTEF [Norway]

ANAS S.p.A. [Italy]

This page is intentionally left blank

CEDR Call 2012: Noise: Integrating strategic noise management into the operation and maintenance of national road networks

DISTANCE: Developing Innovative Solutions for TrAffic Noise Control in Europe

Issues and Assessment of Data Types related to CNONNOS-EU Requirements

Due date of deliverable: 12/2014
Actual submission date:
Draft submission: 26-06-2015
Final submission: 07-10-2015

Start date of project: 01-09-2013 End date of project: 30-06-2015

Author(s) this deliverable:

Herold Olsen (SINTEF)

Quality Review:

On behalf of the Lead Author's Institute				
Author:	Name	Herold Olsen	Signature	Herold Olsen
Technical Reviewer:	Name	Luc Goubert	Signature	

Version: Final Report, 06/2015

This page is intentionally left blank

Table of contents

This page is intentionally left blank

Executive summary

The objective of this WP is to list and assess data that should ideally be provided by the NRAs, above and beyond that which is already collected, in order to produce more robust strategic noise maps and action plans in the future, in accordance with requirements described by the CNOSSOS-EU project.

The focus is on selected data types concerning road surfaces, noise barriers, traffic data and geospatial data. It is within the scope of the work to explore the implications of new requirements and recommendations, examine related problems and challenges in the NRAs, and give recommendations for future data capture.

In this WP we assume that general knowledge about noise mapping related to new CNOSSOS-EU requirements can be aggregated from selected CEDR members combined with expert analyses within the DISTANCE consortium. The extent of the study and its results is however limited to the data types focused on in the objectives, and the general limitations imposed by the WP budget.

This work package has been carried out in three steps.

<u>In step 1</u> a study was made of the requirements given by CNOSSOS-EU, present guidance material related to road traffic noise, and existing documents on practice for strategic noise mapping among CEDR members. The purpose was to make a list of issues which are expected to be of importance to the NRAs in the next round of strategic noise mapping. These documents were considered:

- EC / 2002: Directive 2002/49/EC OF THE EUROPEAN PARLIAMENT AND THE COUNCIL – relating to assessment and management of environmental noise (END)
- WG-AEN / 2006: Good Practice Guide for Strategic Noise Mapping and Production of Associated Data on Noise Exposure
- JRC / 2012: Common Noise Assessment Methods in Europe (CNOSSOS-EU)
- CEDR / 2013: Best practice in strategic noise mapping

<u>In step 2</u> a questionnaire survey was conducted among selected CEDR members to collect updated knowledge about how individual countries plan to adapt to new CNOSSOS-EU requirements. It was developed and sent to 15 countries. The selection of countries was made to cover different geographical regions of Europe with potential representative countries. It included the countries funding the DISTANCE project. 12 of the 15 countries responded by answering the questions. They are Finland, Sweden, Norway, Germany, The Netherlands, Belgium (Flanders), France, Scotland, Ireland, Switzerland, Italy and Spain.

<u>In step 3</u> the answers to the questionnaire were arranged in a way that made it easy to compare practices and challenges between countries and extract findings for further analyses and conclusions. Based on this, observations were identified and recommendations for further NRA work to fulfil CNOSSOS-EU requirements were formulated.

The results of the three steps are summarized in the following table. It is the list of themes and data types considered in this work package, together with a short indication on the fulfilment of corresponding CNOSSOS-EU requirements and our recommendations for further efforts by the NRAs to close gaps. In addition we have indicated if we suggest that the efforts should rely on co-operation across several countries, or should be made internally by the concerned NRAs alone.

Group of data	**Data type**	**Are the NRAs prepared for new requirements?**	**What needs to be done by the NRAs**	**Co-oper. across NRAs**
Road Surfaces	Pavement Type	Yes. Categories are based on physical parameters. But some have low coverage.	Adapt to the coming ROSANNE unified method for classification. Do translations to spectral α- and β-coefficients. Do national investigations to establish average effects, or to underline other conclusions.	Yes
	Pavement Degeneration	No. Except for a few countries.		Yes
Noise Barriers	Barrier Type	These data types are not investigated specifically in this study because of lack of support in the calculation methods, including CNOSSOS-EU		
	Barrier Transmission			
	Barrier Degeneration			
	Barrier Top			
	Barrier Dimension	Yes, for most countries.	For some countries: Improve precision. Invoke national GIS mapping agencies.	No
	Barrier Position			
	Barrier Absorption	Yes, for most countries.	For some countries: Start collecting absorption data	No
Traffic Data	Vehicle Category	Yes. Although some are still in the adaption process	Keep up the good work.	No
	Speed	Yes for DEN-distribution. But most countries do not use actual speed.	Estimate actual average speed for each vehicle category.	Yes
	Quantity	This is implicitly covered by "vehicle category" above		

Geospatial Data	Topography	Yes. Although a few countries have low resolution	A few countries should increase the topography resolution	No
	Ground Surface	No. Most countries do not have easy access to graded surface data	Considerable efforts are needed to provide data by the 8 classes	Yes
	Road Information	Yes (probably)	Keep the attention up	No
	Building geometry	Yes	Keep attention on building heights	No
	Population per building	Yes, for most countries	For some countries: Work towards specific numbers or more diverse statistics	No
	Population distribution over façades	Yes, for some countries No, for others	Co-operate to find common approaches and practices	Yes
	Building Type	This is implicitly covered by data sets on buildings		

The overall conclusion of this work package is that the NRAs seem to be well prepared for the CNOSSOS-EU requirements limited to the themes of the present study. But for some issues more work need to be made by many NRAs before the requirement is fulfilled. This seems especially to be the case for providing data for *pavement degradation*, *ground surfaces* and *population assignment to building façades*. In addition single issues need to be addressed by individual NRAs. Among these we recommend that issues on *pavement type acoustics*, *speed distribution over vehicle categories*, *ground surface* and *population assignment to façades* should be addressed internationally across several NRAs.

We find no prominent regional differences in this study, such as systematic difference between northern and southern Europe. Nevertheless, many of the challenges related to CNOSSOS-EU requirements are similar for several countries. We therefore see an obvious advantage in discussing issues and finding solutions across the NRAs, even though the issue may be of local nature. Any NRA may benefit in co-operating with a neighbour country that already may have solved the issue. This will also contribute to the underlying intention of European harmonisation.

1 Introduction

Work Package 2 is one out of seven parts of the DISTANCE project. The objective of the DISTANCE project is to provide the National Road Administrations (NRAs) with information and guidance on the "state-of-the-art" of practical mitigation measures, data requirements for future action noise mapping and action planning, future potential traffic scenarios and improving public perception, awareness and acceptance of noise mitigation.

1.1 Objectives of the deliverable

The objective of this WP is to list and evaluate data that should ideally be provided by the NRAs, above and beyond that which is already collected, in order to produce more robust future strategic noise maps and action planning, in accordance with requirements described by the CNOSSOS-EU project.

The focus is on selected data types concerning road surfaces, noise barriers, traffic data and geospatial data. It is within the scope of the work to explore the implications of new requirements and recommendations, examine related problems and challenges in the NRAs, and give recommendations for future data capture.

1.2 Strategy and description of techniques used

In this WP we assume that general knowledge about noise mapping related to new CNOSSOS-EU requirements can be aggregated from selected CEDR members combined with expert analyses within the DISTANCE consortium. The extent of the study and its results is however limited to the data types focused on in the objectives, and the general limitations imposed by the WP budget.

This work package has been carried out in three steps.

- A study of the requirements given by CNOSSOS-EU, present guidance material related to road traffic noise, and existing documents on practice for strategic noise mapping among CEDR members.
- A questionnaire survey among selected CEDR members to collect updated knowledge about how individual countries plan to adapt to new CNOSSOS-EU requirements.
- Analyses and evaluation of collected knowledge, and provision of recommendations to ensure a uniform and smooth accomplishment of coming strategic noise mappings.

2 Work tasks

2.1 CNOSSOS-EU requirements

2.1.1 Studied documents

In the initial work of WP 2, several documents were studied. The purpose was to make a list of issues which are expected to be of importance to the NRAs in the next round of strategic noise mapping. These documents are evaluated in the context of the WP2 objectives:

- EC / 2002: Directive 2002/49/EC OF THE EUROPEAN PARLIAMENT AND THE COUNCIL – relating to assessment and management of environmental noise (END)
- WG-AEN / 2006: Good Practice Guide for Strategic Noise Mapping and Production of Associated Data on Noise Exposure
- JRC / 2012: Common Noise Assessment Methods in Europe (CNOSSOS-EU)
- CEDR / 2013: Best practice in strategic noise mapping

The END document is of superior nature, and does not give many details on how to handle specific issues on input data for the calculations.

The WG-AEN Guidelines to END provides a comprehensive supplement to the END document, outlining a large range of detailed issues and providing tools to deal with them. In addition to clarifying many details in the basic methods, this document gives useful practical guidance on how to deal with limited or missing input data.

The CNOSSOS-EU document is a detailed description of methods to use in coming mapping rounds. In many areas, the described methods are new, extended or more precisely defined, compared to the requirements to previous mapping rounds. The new requirements raise many issues that the NRAs need to deal with. In the following text we have limited the issues to those data types that are specified in WP2 of the DISTANCE project.

The CEDR Best Practice document provides very useful insight into how the NRAs managed a wide range of issues raised in the first round of strategic noise mapping. This also provides insight into what may be problematic related to CNOSSOS-EU. But, even though this document is published in 2013, the contents do not seem to be updated since about 2010, and hence do not contain experiences from the second mapping round made in 2012.

2.1.2 Status of CNOSSOS-EU by September 2015

The methods described by the CNOSSOS-EU report are embedded into EU law (Directive 2015/996) on 19th May 2015.

During the work at JRC for developing the methods, a document titled "Guidance for the competent use for strategic noise mapping purposes" was announced. A sketch was made for this document, but the actual content has not been developed yet. A contact in the European Commission states that the guidelines *are for potential further development with the EU Member States in the next years.*

2.1.3 Selected data types

The following is a list of data types of interest to WP2, with corresponding comments related to the documents mentioned above.

Group of data	Data type
Road Surfaces	Pavement Type
	Pavement Degeneration
Noise Barriers	Barrier Type
	Barrier Dimension
	Barrier Position
	Barrier Absorption
	Barrier Top
	Barrier Transmission
	Barrier Degeneration
Traffic Data	Vehicle Category
	Speed
	Quantity
Geospatial Data	Topography
	Building Height
	Road Information
	Building Type
	Ground Surface

This list of selected data types is limited to those data types specifically mentioned in "Description of work" for WP2. Decisions on which parameters to include or exclude were made before initiation of the project. Therefore the list appears as a premise for the present study.

Note that in the following survey, analyses and conclusions some parameters are rephrased or split in order to better underline their meaning. For instance the parameter "Building Type" has been split into the terms "Population per building" and "Population distribution over façades".

2.1.4 Comments related to each data type

In the following paragraphs each of the selected data types are explored and commented in the context of the WP2 objectives.

Data group: Road Surfaces

Data Type: "Pavement Type"

A review should be undertaken about surface classification schemes to determine suitability for software and transferability between MS. CNOSSOS-EU requires pavement type corrections as spectral α- and β-coefficients for octave bands from 125 Hz to 4 kHz. (α is the noise surface correction at reference speed while β gives the deviation factor for other log-relative speeds.) Toolkit 5 in WG-AEN Guidelines to END is related to this data type..

Data Type "Pavement Degeneration"

This data type is not mentioned in END or the WG-AEN Guidelines to END. However, it is introduced in CNOSSOS-EU (page 41) as a mandatory parameter. This means it is a new requirement. The reason for this parameter is that most surfaces tend to produce more noise as they degenerate over their lifetime. This is especially prominent for low noise porous pavements. But instead of requiring data for this progressive increase in noise as a function of pavement age, CNOSSOS-EU asks for the use of the "average effect over the representative lifetime". A procedure for this is announced to be included in future CNOSSOS-EU guidelines.

Data group: Noise Barriers

Data Type "Barrier Type"

Different types of noise barriers may have different noise attenuation characteristics. This may depend on properties such as its shape, surface or mass (weight). A thin glass wall would for instance cause significantly more sound transmissions and reflections than a mound with the same height. Or a curved screen cross-section leaning towards the road centreline will normally perform better than a straight vertical one. Also, different types may have very different degradation progress over their lifetime and therefore perform significantly different after a number of years. Since barriers are the single most used asset in managing or reducing road traffic noise, the possibility to elaborate barrier types may be of special importance in action planning.

However, differentiation between barrier types is not addressed as a stand-alone issue either in END, the WG-AEN Guidelines to END, or in the CNOSSOS-EU specifications. The reasons may be lack of data to quantify differences in noise attributes between barrier types, and lack of methods to deal with such differences. Consequently we have chosen not to raise questions related to barrier type in the following inquiries.

Data Type "Barrier dimension"

The height of the top rim of noise barriers is a critical parameter in many situations. Small height errors may lead to large deviations in noise level if the propagation rays intersect the barrier close to this rim.

Often the available GIS-based information on barrier height is erroneous or missing. This calls attention to the need of good supplementary data sources and good procedures to merge them into the 3D model of the calculation tool. Consequently the WG-AEN Guidelines to END has a toolkit (toolkit 14) dedicated to this issue.

Data Type "Barrier Position"

The WG-AEN Guidelines to END pinpoints the issue that the barrier must be positioned correctly. This is because barriers most often are located close to the sources, and have significant influence on sound propagation. This issue is particularly important in the context of action planning.

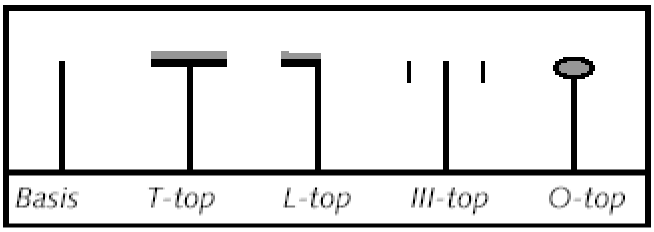
Sometimes this issue is about quality of general digital maps, discussed under "Geospatial Data" below. But often the challenge relates to supplementary data on noise barriers from specific field inventories. In these cases the issue typically is about uncertainties in translation from road segment based location into regular GIS coordinates.

Data Type "Barrier Absorption"

This is parameter is listed in the WG-AEN Guidelines to END together with absorption of building façades. It recommends a toolkit (toolkit 16) for dealing with situations of poor or missing data. The topic is not specifically addressed in CNOSSOS-EU.

Barrier Top

The geometric shape of the barrier top is sometimes constructed specially to achieve more noise reduction than obtained by a basic thin screen at the same height. The effect of such shapes is to reduce the diffraction of sound over the edge.



This parameter is not handled in CNOSSOS-EU and not included in the calculation method. Consequently there is no requirement for collecting or using this data type. Also, it is not mentioned in the WG-AEN Guidelines or the CEDR report.

We have chosen we have chosen not to raise questions related to barrier top in the following inquires. Nevertheless we anticipate that requirements will be raised in the future for providing this parameter.

Data Type "Barrier Transmission"

If the barrier is built by light-weight wooden material or contains "leakages" (like slits or holes), either by design or because of degeneration, the barrier effect may be significantly reduced because of sound transmitting through the structure. This is an issue that has not been addressed by END, the WG-AEN Guidelines to END, or in the CNOSSOS-EU report.

We recognize that the issue will raise the need to enhance the sound propagation model, because it does not comply with the diffraction assumptions in present methods for calculating the barrier effect. The topic is not covered by CNOSSOS-EU core methodology, and the calculation programs are likely not to support this data type. The conclusion is therefore to drop this data type from the following inquiries.

Data Type "Barrier Degeneration"

More recent research indicates that some barrier types may degenerate over time leading to severe reduction of the shielding effect. This can for instance be true for certain wooden constructions. In many cases this degeneration is systematic and predictable. But since this data type is not required by any of the reference documents, we have chosen to drop it from the following inquiries.

Data group: Traffic Data

Data Type "Vehicle Category"

It seems that END has no requirements on which vehicle categories to use, or how to classify the traffic fleet into such categories. Subsequently this is not mentioned in the WG-AEN Guidelines to END. But the CEDR Best Practice document notes that a future requirement for five classes can be very expensive. This important topic actually seems to be new in CNOSSOS. In the first round of strategic mapping, handling of traffic composition were in reality only motivated by the capabilities of the calculation method and data available in each MS.

However, CNOSSOS-EU introduces the following specific requirements for vehicle categories:

1 Light motor vehicles
2 Medium heavy vehicles
3 Heavy vehicles
4 Powered two-wheelers:
  4a mopeds
  4b more powerful motorcycles
5 New / Future vehicles (optional)

Data Type "Speed"

CNOSSOS-EU requires the use of average speed for each vehicle category, with the optional correction for acceleration/deceleration near stop-signs or junctions. The WG-AEN Guidelines to END recommend relying on actual speed based on traffic flow models, if real monitoring data is not available. However speed data from such models normally must be adjusted to reflect the actual average speed. It is recommended to distinguish between the speeds at *day*-, *evening*- and *night-time*. A toolkit (toolkit 3) is provided to close gaps. In addition the CEDR Best Practice document considers the issue and recommends the MS to use actual speed instead of sign-posted speed in future strategic noise mapping.

Data Type "Quantity"

The traffic quantities shall be expressed for each vehicle category in combination with the *day*-, *evening*- and *night-time* periods. In many cases it may be difficult to obtain exact numbers for complete data sets for all roads under consideration. The WG-AEN Guidelines to END has recommendations for how to deal with different kinds of shortcomings, and provides toolkits (toolkit 2 and 4). It also suggests how to distribute traffic across multilane roads. The CEDR Best Practice document does not elaborate on the issue, but expresses concern that the introduction of several vehicle categories may become expensive.

Data group: Geospatial Data

Data Type "Topography"

The shape of the terrain is normally described by the variation of ground height over a horizontal plane. Typical sources are elevation contours from digital maps, grid-based elevation models (DEM) or high-resolution raster models from laser scanning by airplane (LIDAR). The WG-AEN Guidelines to END recommend the use of DEM-models with additional corrections for embankments and cuttings along the noise emitting roads in question.

Data Type "Building Height"

The height of buildings is an important parameter for calculation of shielding and sound reflections. Even though digital vector maps normally have a high quality in positioning the horizontal outline of buildings, they often fail to provide precise information about the height. In addition the roofs may be shaped in many different ways, which complicates the process of fetching and interpreting plausible values for this parameter. The WG-AEN Guidelines to END has recommendations on how to deal with different levels of data, ranging from precise info from 3D building objects to rough estimations in cases of no specific information on the heights of a building. It also provides guidance on how to simplify height information when the provided geospatial data is too detailed. See toolkit 15. The issue is also addressed by the CEDR Best Practice document, which recommends utilizing information on number of floors in the building.

Data Type "Road Information"

This parameter is not about pavement type, which is handled above (please see Data Type: “Pavement Type”). But it recognizes the fact that the geometric shape of the road is of special importance, since the road traffic sources are so closely connected to the road.

In many cases the details about embankments and cuttings are not reflected in the basic topography data, which therefore have to be corrected from road information, provided as supplementary geospatial data. In the WG-AEN Guidelines to END the issue is dealt with in connection to topography (toolkit 11 and 12).

Additionally the gradient of the road influences the vehicles as noise sources. In case the gradient cannot be derived correctly from the topography data, it may be supplied as supplementary road information from geospatial data sources.

Data Type "Building Type"
To calculate the correct noise impact in the mapped areas, it is required to connect the calculated noise levels on building façades to the number of people living in the building. To do this we first need to separate dwellings from other buildings. Then we need to know the number of dwelling units, find their distribution across the façades and count the number of exposed people in each noise level interval. The challenge in this process is to connect calculated noise levels to building type information (from GIS), and general census data sources for the community. It is therefore about more than just GIS-related spatial data. The challenge is to find efficient methods that can provide consistent results with an acceptable quality, across the MS. This issue is addressed thoroughly by the WG-AEN Guidelines to END which provides appropriate toolkits (toolkit 20 and 21). Also the CEDR Best Practice document mentions this issue and expresses great difficulty managing it in a good manner across the NRAs. CNOSSOS-EU contributes to solving the issue by providing explicit definitions and methods on the topic.

Data Type "Ground Surface"
This is another parameter that is normally derived from general purpose digital maps. While previous strategic mapping distinguished between two surface types (*soft* and *hard*), CNOSSOS-EU specifies 8 ground surface classes. It is expected to be a challenge for many MS to translate general ground types from digital maps into these classes. Another issue may be how to simplify surface information which often is provided in too much detail in regular digital maps.

2.2 Survey among selected CEDR members

2.2.1 The survey

After finishing the task of exploring CNOSSOS-EU requirements and related documents, a questionnaire survey was developed for collecting knowledge from NRAs responsible for national noise mapping.

The questionnaire was limited to data types focused on by the project objectives.

Most of the questions were formulated with multiple choice check boxes ranging from full compliance with corresponding requirement to different alternatives for incomplete or missing data. The purpose was to be able to compare national practice and capabilities with the requirements, and find equalities and differences across neighbor countries and regions in Europe.

The questionnaire with covering letter is shown in Appendix A. It was sent to the NRA or other relevant institution in the following countries (ordered geographically).

Country	Inquired by	Answered
Finland	SINTEF	Yes
Sweden	SINTEF	Yes
Norway	SINTEF	Yes
Denmark	SINTEF	No
Germany	BRRC	Yes
The Netherlands	BRRC	Yes
Belgium (Flanders)	BRRC	Yes
France	BRRC	Yes
United Kingdom (England)	TRL	No
United Kingdom (Scotland)	TRL	Yes
Ireland	TRL	Yes
Switzerland	ANAS	Yes
Austria	ANAS	No
Italy	ANAS	Yes
Spain	ANAS	Yes

The selection of countries was meant to cover different geographical regions of Europe with potential representative countries. It includes the countries funding the DISTANCE project. A few countries have not responded to the survey despite repeated reminders.

2.2.2 Answers to the survey

These are the answers from each country collected in a comparable way.

2.2.2.1 Theme 1: Road Surfaces

Question 1A: What kind of categorisation of road segments do you use for NRA roads in your country? Please provide supplemental documentation if available.

Finland	There is no data about pavement types related to road segments. But in Finland so called SMA 16 or SMA 20 pavements are used mostly. Age correction for pavement is used in calculations. http://www.digiroad.fi/en_GB/
Sweden	Chipping size (8, 11, 16 mm), porosity (for PAC) and type of pavement SMA, DAC, PAC, Table 3 on page 12-13 in supplemented documentation.
Norway	Pavement category (SMA, AC, AgC…)- Chipping size (8,11, 16) - Age - Width (road width 3-10 meter).
Germany	Table 4 in VBUS and additional general circulars of road construction http://www.bast.de/EN/FB-F/Subjects/e-vbus/e-vbus.html and http://www.bast.de/DE/FB-F/Fachthemen/f3-vbus/f3-vbus.html for download.
The Netherlands	In the Netherlands, we use a categorization based on physical parameters.
Belgium - Flanders	14 pavement type corrections as spectral α- and β-coefficients for octave bands from 125 Hz to 4 kHz
France	For the purpose of noise mapping, 3 categories of road pavements are defined: R1 (low noise), R2 (medium) and R3 (noisy pavement). Each category corresponds to types of pavements. They have been established from statistical analysis of large database of SPB measurement results.
UK - Scotland	Typically, road segments are described as either Hot Rolled Asphalt (HRA) or Stone Mastic Asphalt (SMA).
Ireland	Pavement management system principal categorisation is by (i) pavement type (ii) traffic volume (i) surface type.
Switzerland	For each road segment the following parameters must be homogeneous: Traffic load, sign-posted speed, slope, road surface.
Italy	At the time being categorisation is based on roughness (IRI) and bearing capacity. We expect to provide more accurate information on acoustic characteristics of pavements through the use of a recently developed CPX measurement system

Spain	The categorisation of road segments used in Spain for NRA roads is: Dense asphalt concrete, porous asphalt, thin layers and cement concrete. Specifically, Spain spent a three pavements categorisation for the second programme phase of strategic noise maps: Dense asphalt concrete, Porous asphalt, Cement concrete.

<u>Question 1B:</u> How much of the NRA road network in your country is currently categorised in accordance with your categorisation scheme?

	Practically all road segments	Some of the road segments	Approx. percentage	None of the road segments
Finland	x			
Sweden	x			
Norway	x			
Germany	x			
The Netherlands	x			
Belgium - Flanders	x			
France		x	50	
UK - Scotland	x			
Ireland	x			
Switzerland	x			
Italy		x	5-10	
Spain		x	90	

<u>Question 1C:</u> What efforts do you regard as necessary to fulfil this CNOSSOS-EU requirement in your country?

Finland	
Sweden	We need to investigate and calculate α- and β-coefficients for our road types.
Norway	None.
Germany	Recalculation of national (A-weighted) corrections in spectral (octave-band) values. Until now the procedure to do so is not clear. Therefore we may have to do some retro-engineering.
The Netherlands	Transposition of national coefficients for implementation in CNOSSOS-EU.
Belgium - Flanders	In function of the age of the pavements.
France	To check the conformity of CNOSSOS-EU source model (taken from HARMONOISE model) with French source model (NMPB-source), see ref in question 1A. In particular, the emission coefficients which are defined in 1/3 octave bands whereas the French source model calculates overall levels and applies a spectral pattern afterwards.
UK - Scotland	Unsure how to answer this question, as our knowledge of CNOSSOS is still limited – This is to be confirmed.
Ireland	It seems to be potentially a constantly changing target in some road types. Our network is mixed in volume from 120,000+ AADT to 2,000 AADT and from fully engineered motorways to “legacy” roads of indeterminable engineering standard (geometrically and structurally). Consequently we have for example very low volume roads with much poorer IRI than motorways which can have an influence on noise but usually these areas have low population densities.
Switzerland	All segments have a homogeneous road surface and speed. In general no further segmentation is needed. For each segment the information about α and β could be added.
Italy	Efforts will be mainly addressed to the optimization of the CPX system, in order to provide a reliable road classification.
Spain	In order to ensure that CNOSSOS-EU requirement are properly fulfilled, Spain is going to try to adapt its own categorization to the categorization of CNOSSOS-EU (appendix F, table F.4)

Question 1D: Most surfaces tend to produce more noise as they degenerate over its lifetime. CNOSSOS-EU requires that member states account for the average effect of this over the representative pavement lifetime. How does your NRA plan to meet this requirement?

	Degradation corrections for actual age	Increasing noise for degradation effects	Other method	Please specify
Finland		x		
Sweden			x	No plan this far. Today we don't apply any correction for new "silent" road nor for our few "old" "noisier" roads. We base our mapping for medium-old pavements. Maybe we stick to that old method.
Norway			x	For the next few years we will probably continue using an average effect as a standard value (degradation is included in a value for the specific road surface). We need more research to develop degradation noise corrections.
Germany			x	By using only correction values from road surfaces, which are at least 6 years old.
The Netherlands		x		Dutch road surface coefficients already account for the average effect over the representative pavement lifetime.
Belgium - Flanders			x	We don't know yet
France			x	The current French source model provides rolling noise models for old pavements in each of the 3 categories. They were established for pavements in good condition (no surface defects) but at least 10 year old.
UK - Scotland				Unsure how to answer this question, as our knowledge of CNOSSOS is still limited - This is to be confirmed.

Ireland	x			
Switzerland			x	Predictions for existing roads surfaces: measurements + correction in function of the age of the road surface. Predictions for new roads surfaces (to be build…): characteristic values at the end of life for each road surface type.
Italy		x		
Spain				No revisions are expected, because that will be difficult having data about the real state of the pavement.

2.2.2.2 Theme 2: Noise Barriers

Question 2A: What are your sources of information about noise barrier locations?

	GIS maps		NRA Registers		Other sources		Please specify
Finland	x	75%	x	15%	x	10%	Field surveying.
Sweden	x	5%	x	10%	x	50%	Old barriers on paper in archives. When CNOSSOS is compulsory in 2022 we estimate that 90% of the barriers will be GIS-based.
Norway	x	90%	x	10%			We use digital maps and database data to develop the best available noise barrier dataset.
Germany							This differs in Germany from Land to Land. In some cases flights with ground scanners where conducted. In most cases camera tours with cars have been done to get the needed information. Only in some cases there are registers with this information.
The Netherlands			x	80%	x	20%	20% of the noise barriers come from noise models that have been used in noise assessment studies.
Belgium - Flanders	x	80%	x	95%			
France	x	30%	x	30%	x	40%	Utilisation de GoogleMap
UK - Scotland			x	100%			Noise barrier locations should be captured within the Transport Scotland IRIS system, within a GIS based digital map.
Ireland	x						Currently virtually all of our noise barriers have been installed as a result of a major network development programme since c.1995 so “as built” record drawings should be available, however this is not always the case. Much of the barrier information has been gathered for 2006 & 2012 rounds of Noise mapping based on driven surveys.

Switzerland					x		Existing barriers: the geometry from building plans is used. If the plans are missing, approximations are made. New barriers: the accuracy of the data evolves with the progress of the project. Most of the barriers along the national road network ("ASTRA Network") are collected in a central noise database (MISTRA LBK). The sources of this information are the ongoing noise abatement projects.
Italy			x				
Spain	x	100%					

<u>Question 2B:</u> What is the typical uncertainty of the horizontal position the noise barriers?

	< 0.3 m	< 1 m	> 1 m	Uncertainty indicator
Finland		x		Standard deviation.
Sweden			x	Unknown.
Norway		x		Unknown uncertainty.
Germany				I'm no expert in this.
The Netherlands		x		95% Confidence Interval < 1 m.
Belgium - Flanders	x			Standard deviation
France			x	
UK - Scotland			x	This is to be confirmed.
Ireland		x		Construction accuracy requires maximum horizontal tolerance of +/- 15mm to road alignment. As ancillary works such as barriers are offset from road line this has a higher degree of accuracy.
Switzerland		x		In noise calculation models the accuracy is high. Most barriers have an uncertainty level better than 1 meter. The uncertainty level in the central noise database (MISTRA LBK) is not known.
Italy		x		
Spain		x		

Question 2C: What is the typical uncertainty of the height of the noise barriers?

	< 0.1 m	< 0.3 m	> 0.3 m	Uncertainty indicator
Finland		x		Standard deviation.
Sweden			x	Unknown. When CNOSSOS is compulsory in 2022 we estimate that 95% of the barriers will be GIS-based with better than 0.1 meters.
Norway			x	Unknown.
Germany				I'm no expert in this.
The Netherlands		x		95% Confidence Interval < 0.3 m.
Belgium - Flanders	x			Standard deviation
France			x	
UK - Scotland			x	
Ireland		x		As 2B this was a contract requirement.
Switzerland		x		In noise calculation models the accuracy is high. Most barriers have an uncertainty level better than 0.3 meter. The uncertainty level in the central noise database (MISTRA LBK) is not known.
Italy		x		
Spain		x		

Question 2D: Where relevant, do you take sound absorption into account for noise barriers?

	No	Yes	Please indicate how
Finland	x		
Sweden	x		When CNOSSOS is compulsory in 2022 we estimate that 95% of the barriers will be GIS-based with information of absorption or not.
Norway		x	Data source database (absorption yes/no).
Germany		x	See VBUS.
The Netherlands		x	Based on primary material. In our SRM2 models an absorption factor 0.8 was used for noise absorbing barriers, 0.2 for noise reflecting barriers. Recently, we have determined absorption spectra for cat. A0 to A5.
Belgium - Flanders		x	Standard value of 10 dB absorption.
France		x	Only “absorbing” or “reflecting”
UK - Scotland		x	Where receptors are evident on opposite sides of the trunk road, sound absorption barriers will be specified for new trunk road schemes where applicable. I do not believe that sound absorption is taken into account during the noise mapping exercise.
Ireland	x		
Switzerland		x	For noise calculation an absorption coefficient for noise barriers is applied.
Italy		x	Absorption coefficient.
Spain		x	Spain has considered noise barriers either reflecting or absorbing. When are considered absorbing elements, the absorption coefficients considered is unique. It is 0.21.

2.2.2.3 Theme 3: Traffic Data

CNOSSOS-EU requires five distinct vehicle categories:

1. Light vehicles
2. Medium heavy vehicles
3. Heavy vehicles
4. Powered two-wheelers:
    a. Mopeds
    b. More powerful motorcycles
5. New / Future vehicles (optional)

Question 3A: How do you plan to determine the distribution between the vehicle categories?

	Counting and/or traffic modelling	Regional or national statistics	Separate on road type	Default national distributions	Separate on road type	
Finland	x	x	x			Categories 4 (and 5) will not take account, those are used only (mostly) in summer time May – September and number of two-wheelers or future vehicles are not significant in any road in Finland, it is about 0.5 % of total traffic flow in Finland.
Sweden						We have no plan for vehicle type 2, 4 and 5. We have to work it out long before CNOSSOS is compulsory in 2022.
Norway	x	x	x			
Germany	x					The German wide traffic counting is uses, which is conducted every 5 years.
The Netherlands	x					Distinction between light, medium heavy and heavy vehicles is already existent.
Belgium - Flanders	x					Mostly all over the highway network vehicle counting is possible with a distinction between the vehicle categories. For the remaining roads the vehicle amount will be extrapolated by traffic models based on actual vehicle counting

France	x	x x		The categories 1 and 3 by specific vehicle counting. The categories 2 and 4 by applying generalized countryal or national statistics on vehicle distributions.
UK - Scotland	x			The Transport model for Scotland would be able to make this distinction.
Ireland		x		We have a series of traffic counter loops spread throughout the network at predetermined node points where we expect volume changes. Whereas 1-3 are easily counted by them 4-5 would require a different system so most probably based on a proportion of 1-3 determined by individual traffic counts.
Switzerland	x			In Switzerland traffic counting is using 10 different categories (SWISS 10). The SWISS10 categories correspond to the CNOSSOS-EU classes 1-4.
Italy	x			
Spain				Spain has good real data (from measuring equipment network) of motorcycles, light and heavy vehicles. Currently we are taking a decision about how to determinate the distribution. It is probably that we choose separate distributions of heavy vehicles for different road type.

<u>Question 3B:</u> What day-, evening- and night-time distribution data are you able to provide for your traffic mix?

	Full combination of D-E-N, vehicle category and road	General D-E-N distributions for each vehicle category and road type	General D-E-N distributions for each vehicle category.	Fixed D-E-N distributions	Other	Please specify
Finland	x	x				Traffic quantities are counted from over 200 automatic traffic calculation points LAM -points. In other roads generalized day-, evening- and night-time distributions for each vehicle category and road type combination are used.
Sweden					x	Light and heavy vehicles (1 and 3). Day-Evening-Night.
Norway		x				
Germany	x					See above.
The Netherlands	x					
Belgium - Fland.	x					
France		x				Use of Information leaflet 77 “Calcul prévisionnel de bruit routier Profils journaliers de trafic sur routes et autoroutes interurbaines” *(“Preliminary calculation of road noise Daily traffic profiles on highways and trunc roads”)* SETRA, April 2007 and counting on some high volume roads.
UK - Scotland	x					
Ireland	x					
Switzerland	x					
Italy	x					
Spain	x					

<u>Question 3C:</u> What speed data are you able to provide for your traffic mix?

	Speed for each vehicle category from measurements / modelling	General data for each vehicle category from speed statistics	Sign-posted speed	Reductions for heavy vehicles	Additional corrections for acceleration/deceleration	Other	Please specify
Finland		x	x	x			
Sweden			x	x			
Norway			x				
Germany							
The Netherlands			x	x			The Dutch NRA has established representative speeds per vehicle category, based on speed measurements at various locations.
Belgium - Flanders			x	x	x		
France			x	x			Use of posted speed for the category
UK - Scotland	x						
Ireland			x				
Switzerland			x				In Switzerland sign-posted speed is used for noise calculations. Therefore only this information is collected systematically in the central noise database (MISTRA LBK).
Italy	x						
Spain	x						Spain is able to provide in relation to its traffic mix: real data from measuring equipment network. Annual average data. With maximum speed limit differentiating light and heavy vehicles.

2.2.2.4 Theme 4: Geospatial Data

Question 4A: What kind of topography data are you able to use

	High resolution DEM/LIDAR models	Additional corrections for embankments and cuttings	Low resolution DEM models	Height contours from vector-based GIS maps	No topography data is used	The ground is actually horizontal	Comments
Finland	x	x					
Sweden	x	x	x	x			
Norway	x						We use high resolution topography data, but in some areas we use height contours from vector-based GIS maps.
Germany	x						I'm no expert in this field.
The Netherlands	x	x					Embankments as a part of the National roads are included as barriers in the modelling.
Belgium - Flanders	x						
France			x				Use of digital terrain model of the data base «TOPO» of the French geographical institute
UK - Scotland	x						We have LIDAR data for most of Scotland sufficient coverage for the extent of noise mapping.
Ireland	x						
Switzerland	x						
Italy	x						
Spain							In general for Spain used DEM grid size 25; even better in some cases. It was asked to improve in a band of 100 m on each side of the platform

Question 4B: What kind of ground surface data do you have for noise calculations?

	High resolution maps 8 ground classes	Low resolution maps 8 classes	Rough surface estimates	Other	Specification / comment
Finland			x		
Sweden			x		
Norway				x	We use 7 classes, resolution less than 10 meter uncertainty, probably compliant with the 8 classes defined in CNOSSOS(?).
Germany					Not yet decided! Until now: none.
The Netherlands			x		
Belgium - Flanders			x		
France			x		
UK - Scotland					Unsure how to answer this question. AECOM undertook the noise mapping exercise for Scottish Government, so they would be best placed to answer this question - This is to be confirmed.
Ireland			x		
Switzerland				x	Currently ground surface data is not taken into account. Calculations are based on average conditions.
Italy			x		
Spain			x		

<u>Question 4C:</u> How do you handle detailed information of the road geometry?

	Included in topography model and/or buildings/screens	Derived from road geometry	It is not handled	Other	Specification / comment
Finland	x				
Sweden	x	x			
Norway		x			
Germany					I'm no expert in this field.
The Netherlands	x				In our opinion, it is impossible to apply road gradient corrections on an automated basis since there are too many interpretations to be made and since the direction of digitalization is not always the direction of traffic.
Belgium - Flanders	x				
France		x			
UK - Scotland					Unsure how to answer this question. AECOM undertook the noise mapping exercise for Scottish Government, so they would be best placed to answer this question – This is to be confirmed.
Ireland	x				
Switzerland	x				
Italy	x				
Spain	x				

<u>Question 4D:</u> What road gradient information is available for your noise source calculations?

	Specific gradients are available	Calculated from topography	No road gradients are used	The ground is actually horizontal
Finland	x			
Sweden		x		
Norway	x			
Germany		x		
The Netherlands			x	
Belgium - Flanders		x		
France		x		
UK - Scotland	x			
Ireland		x		
Switzerland		x		
Italy		x		
Spain	x			

Question 4E: What kind of data for buildings and screens do you have for noise calculations?

	Full 3D model	Horizontal outlines	Specific height	Height from building type & floors	Height from type of area	Fixed default height	No specific shape and height	Other	Specification / comment
Finland	x	x	x						
Sweden	x	x	x	x	x	x			
Norway	x	x	x	x	x	x			If available full 3D model else horizontal outlines and specific height information, or else the best available height information (Worst case is default value).
Germany									
The Netherlands		x			x				In addition, behind the first row of buildings in a built up area, we use “Scattering zones”, where the effects of diffraction and reflection by buildings are dealt with by a macroscopic approach.
Belgium - Flanders		x	x						
France		x	x						
UK - Scotland		x	x	x					
Ireland		x				x			
Switzerland		x	x						
Italy	x								
Spain		x							Depending on the region and the available information; we had specific height or number of floors data information.

Question 4F: What kind of population data is available for noise mapping in your country?

	Specific numbers	For each building	For larger entities	Estimated by s floor space	Floor space is known	Floor space is estimated	Other	Please explain
Finland	x	x						
Sweden	x	x						
Norway				x	x			
Germany	x		x					
The Netherlands							x	National default: 2.3 inhabitants per dwelling.
Belgium - Flanders							x	For each address the number of inhabitants is known. This number is allocated to the nearest building.
France	x		x	x		x		
UK - Scotland				x		x		
Ireland	x		x					
Switzerland	x	x						
Italy				x		x		
Spain	x		x					

Question 4G: How are your building façade data described?

	Façade outlines are known	Façade outlines are estimated from building data	Please explain how
Finland	x		
Sweden	x		
Norway	x		
Germany	x		
The Netherlands		x	Assignment of inhabitants to noise classes is done by combination of noise contours and center points of the dwellings. We do not use the exact location of the (most exposed) façade.
Belgium - Flanders	x		
France	x		
UK - Scotland	x		Scottish Government is still considering how best to address this issue under CNOSSOS.
Ireland		x	This exercise has not been completed for the network hence given the diverse nature of the network an estimate is the most likely methodology to address this issue.
Switzerland	x		For the noise calculation the buildings are described with vector-based polygon. In the central noise database buildings are described as points (=> no information about the façade outline).
Italy	x		
Spain	x		

2.3 Analyses and discussion

2.3.1 Road surfaces

All the countries who answered the questionnaire have a system for categorizing road surface types (Q-1A), which is relevant for calculating road noise production. It turns out that the characterisation systems differ a lot throughout Europe. However all countries base their categories on physical parameters that are relevant for noise. Parameters vary from chipping size in the Nordic countries to pavement type, texture, density and porosity in middle- and southern Europe.

The diversity in systems and parameters is probably because of historic reasons with independent developments in each country. In addition geographical differences in climate and traffic constitute valid objective reasons for having different category systems in different countries. The MS should be aware that in the EU FP7 project ROSANNE a unified method is elaborated. This will be outlined in a draft EN standard which will then follow the usual way for approval through the CEN procedures. The compatibility with the CNOSSOS calculation method is especially taken into consideration. It is highly recommended that all MS adapt this method for classifying acoustically pavements as soon as the new standard will be published, which should happen in 2017 or 2018.

Most countries in the study have a high coverage of the road network registered in accordance with their categorisation system (Q-1B). The inquiry indicates, however, that Italy and perhaps France still need to more registration work to get a good coverage of their road network.

At the time being, the majority of the countries in the study do not have their road categories translated to the spectral α- and β-coefficients for octave bands, as required by CONSSOS-EU. Belgium – Flanders and Switzerland are exceptions (Q-1C). For many countries filling this gap is really a question of implementing existing knowledge on relationship between physical parameters and noise emission. An existing CEN work (CEN/TC227/WG5) is presently preparing international guidance on this topic. For others, more research (like CPX measurement campaigns) needs to be executed before the coefficients required by CNOSSOS-EU are in place.

We recommend that countries with equal or similar characterisation parameters co-operate in the efforts to establish the relevant spectral α- and β-coefficients for their surface types.

The requirement from CNOSSOS-EU to account for degeneration of road surfaces is more difficult to assess (Q-1D). Some of the countries report that aging effects are included imperially in the road surface data. Others are uncertain or have no plan to do any specific effort to meet this requirement. Only Ireland reports to use the actual pavement age for degradation assessment.

In many cases road degradation shows a logarithmic dependency on time (Hammer et al, 2015). In the scope of CNOSSOS-EU it is perhaps best to deal with degradation in a average manner adapted to the local conditions in each country. Thus the approach of including aging effects in the general average surface data may prove the best way to fulfil this CNOSSOS-EU requirement.

We recommend that countries that presently do not include degradation effects, should make an effort to investigate the phenomena and make a documented argument on how to assess this requirement. We anticipate that a statistical approach that averages over pavement lifetime will be satisfying. In many cases however, much relevant information can be found in literature from national and international studies, e.g. (Kragh 2008; Kragh ea 2013; Kragh ea 2008 and Kragh ea 2012)

If this turns out to be insufficient, we recommend transnational or international research collaboration to fill the remaining gaps, as many countries have similar climate and traffic conditions combined with similar pavements.

2.3.2 Noise barriers

It seems that there is a high focus on barriers in road noise calculations throughout Europe (Q-2A). Most countries in the study have GIS-based registers covering most of the roads, while others are building up such registers with the aim of sufficient readiness by the time the CNOSSOS-EU requirement becomes compulsory. Geometric position information typically origin from high precision sources like construction plans, GIS mapping surveys or flight scanning. But some countries (like France and parts of Germany) report that data is collected by presumably more approximate methods like camera tours with cars or utilization of Google Maps.

For most countries the geometrical precision is reported to be better that 1 m horizontally (Q-2B) and better than 0.3 m vertically (Q-2C). With this level of precision we regard the requirement of CNOSSOS-EU to be fulfilled.

For countries with less precision we recommend that effort should be made to improve the screening data quality. Since this work normally is connected to national GIS mapping strategy, we see no obvious advantage from international co-operation. The effort should be made within each specific country.

The requirement of taking sound absorption into account is met by most countries in this study (Q-2D). Only Finland and Ireland seem to lack this regard, despite having high register coverage with accurate data.

We recommend that countries that do not have barrier absorption information should make an effort to register such data to be able to include it in the future. Otherwise this important CNOSSOS-EU requirement will not be fulfilled. As for geometrical positions, the effort to include absorption information should be made within each specific country.

2.3.3 Traffic data

The collection and use of traffic data has long traditions across all European road administrations. This is not only driven by noise issues, but serves many purposes like capacity or safety related issues. All countries in the study have good quality data based on traffic counting and/or traffic modelling, sometimes supplemented by regional statistics (Q-3A). The CNOSSOS-EU requirement for 4 - 5 traffic categories is an extension compared to earlier END directive specifications. Although some countries (like Finland, Sweden and Ireland) do not presently cover new vehicle categories like powered two-wheelers and perhaps medium weight vehicles, there is apparently a drive to fulfil this CNOSSOS-EU requirement.

We recommend that countries which do not yet fulfil this requirement make the necessary efforts to close the gap. In reality the work seems to be about splitting existing traffic categories down to a more refined level, as required. Countries with similar challenges in this matter may benefit from co-operating on the methodology.

All countries in the study are able to provide day- evening- and night-time distributions for each combination of vehicle type and road type (Q-3B). Most countries are even able to provide this separately for single roads. It therefore seems easy to fulfil the CNOSSOS-EU requirement regarding time distributions.

For most of the countries in the study, information about speed is set to sign-posted speed for each road segment (Q-3C). A few countries (Norway, Ireland and Switzerland) do not reduce heavy vehicles speeds to their upper limits. Since CNOSSOS-EU requires use of actual average speed for each vehicle category, most countries need to make an effort to enhance the traffic speed information for their road network. UK – Scotland, Italy and Spain seem to be the exception, since they already report to use actual speeds.

We recommend that actual average speed data primarily should be derived from traffic counting systems or traffic modelling. For many countries the corresponding effort is a question of exploiting or perhaps enhancing existing traffic counting or modelling systems. To other countries, we believe that valuable information can be derived from statistical data from close neighbour countries. Thus, international co-operation is expected to benefit the efforts to fulfil this requirement.

2.3.4 Geospatial data

CNOSSOS-EU requires that the shape of the terrain is taken into account. Over the recent two decades several kinds of general purpose topography models have been developed for most of the world. The requirement is that they shall be utilized in road noise calculations. All countries in the study report that they have access to high resolution topography data for their calculations; typically 10 meter grid size or better (Q-4A). France and Spain are exceptions with somewhat lower resolutions; typically 25 - 30 meter grid size.

The importance of the topography model resolution and precision depends of course of on whether the terrain is hilly or not. For a flat horizontal terrain, the topography model does not add any precision to the calculation. But in very hilly terrain the quality of the topography model is crucial.

We recommend that countries with non-flat terrain make an effort to ensure that their terrain model has horizontal resolution of 10 meters or less, and a typical vertical accuracy better than 1 meter. Normally this kind of data should be available from the national mapping agency in the country. For most countries this is available, and should act as a fulfilment of the CNOSSOS-EU requirement for topography.

Another important aspect of the terrain is the ground surface. CNOSSOS-EU requires categorizing the ground in 8 classes, and assumes input data to be derived from GIS maps. None of the countries in the study meets this requirement at the time being (Q-4B). Norway is an exception with use of 7 classes derived from high resolution maps. The rest of the countries report either only using rough estimates for ground surface or none at all.

It is evident that considerable efforts are needed if the member states shall be able to fulfill the new CNOSSOS-EU requirement for detailed ground surface. The efforts may include investigations in each country to identify suitable data sources within their GIS mapping regime. And to define schemes to translate this information into the specified ground classes. This translation effort probably also must include consideration on how to convert general purpose GIS formats and resolutions into data sets compliant with the calculation tool. We believe that some of these efforts will benefit from international co-operation, especially between countries with similar GIS mapping regimes.

We recommend that necessary steps are taken by each country to fulfil the CNOSSOS-EU requirement for including detailed ground surface data. In case this is impossible to do for economical or technical reasons, we recommend using rougher estimates for ground surfaces based on any knowledge of local terrain at the calculation sites. It is after all far better than ignoring this effect completely.

When it comes to the detailed road geometry such as embankments, cuttings, slope and tilt, most countries in the study report that this is treated specially (Q-4C). The information typically is included in the topography model or added to the calculation process as extra road geometry data. The study does not reveal the quality of such special attention to the road geometry, other than a confirmation that the topic has attention across the countries. Quality aspects will depend on local height variations compared to the resolution and precision of the topography model.

We recommend that every country focuses on possible errors in noise calculations due to uncertainties in geometry data at or close to the roads. For most countries this is be the case, which supports compliance with CNOSSOS-EU requirements.

A closely related issue is input data about road gradient as a parameter to calculate the noise sources. Hilly roads produce more noise than horizontal roads because of higher engine load and increased use of brakes. A majority of the countries derive road gradient data from the underlying topography model (Q-4D). But a few countries (Finland, Norway, UK – Scotland and Spain) use special gradient data from other sources with presumed better quality. In The Netherlands no road gradient data are used, obviously because hills are not a prominent feature of this country.

For those deriving gradient data from topography models, it is worth mentioning that fluctuations in topography height that deviate from the actual road geometry can cause systematic errors in the calculated noise. This should be dealt with in the algorithms for calculating the gradient, for instance by smoothing or similar methods. Provided that this is done, we observe that road gradient data appears to be properly managed by the countries in this study. We see no need for further recommendations on this issue.

For geospatial information about 3D objects such as buildings and screens, all countries have GIS data for the 2D horizontal outlines (Q-4E). Thus, it seems easy to fulfil the requirements of quality for position and orientation of objects that influence the noise by sound screening, reflection and diffraction phenomena. Precise information about the height of such objects is especially important when the top of the object is close to the line-of-sight between the source and the receiver. This is typically the case in hilly terrain. In other cases, for instance for high buildings on horizontal ground, a rudimentary estimation of the height is regarded to be good enough. The source of information for object heights varies across the countries in this study. The majority have a specific height for each building. The Netherlands derive building heights from the type of area, which seems plausible on flat land. Ireland reports to use only default heights, which contributes to the uncertainty on the calculation results.

It is difficult to give general recommendations on the issue of building height based on this study. However we recommend individual countries with scarce building height information to focus on developing such data sets. We expect that the increasing demand for general 3D data for visualization purposes could be exploited in the field of noise calculations.

For assessing noise impact, CNOSSOS-EU puts attention on assigning calculated noise to the people exposed to it. The source of information about population for each building is varying across Europe (Q-4F). A majority of the countries have specific number of residents in each building. This will obviously fulfil the CNOSSOS-EU requirement. Others estimate the numbers from population in the area and distribute statistical numbers based on physical parameters such as floor space. Again it is difficult to give general recommendations. The availability of data may be limited by national traditions or regulations that are hard to overcome. But we believe that for countries with low population data resolution, such as Norway, Scotland and Italy, the focus on this issue from CNOSSOS-EU can be used to drive the development for better noise exposure estimates.

The final question is about the distribution of inhabitants over building façades. The answers indicate that façade outlines exist as required (Q-4G). But for several countries this CNOSSOS-EU topic requires a new approach on how to assess noise exposure. For countries like The Netherlands and Switzerland the requirement demands change compared to present practice. For others like Scotland and Ireland the issue is under consideration.

We recommend that each country make an effort to meet the requirement for how to assign population data to different calculation points on the building façades. Issues on this topic seem to be common to many countries, so we recommend discussing the matter among the member states in order to find common approaches, methods and practices. In addition to the pure technical aspects, this topic is really about noise mapping policy. Fulfilling this requirement is therefore an important task in order to reach overall goals of European harmonization.

3 Conclusions and recommendations

In the present work package we have listed and assessed data that should ideally be provided by the NRAs, above and beyond which is already collected, in accordance with requirements described by the CNOSSOS-EU project. The work has been limited to themes covering road surfaces, noise barriers, traffic data and geospatial data.

An evaluation has been made of the CNOSSOS-EU report describing calculation methods and requirements for input data, together with related normative documents and existing guidance material. Additionally a questionnaire survey has been conducted among selected European countries. The results are used to explore how the requirements managed, and to suggest recommendations for NRAs on how to close possible gaps.

The following table is a list of themes and data types considered in this work package, together with a short indication on the fulfilment of corresponding CNOSSOS-EU requirements and our recommendations for further efforts by the NRAs to close gaps. In addition we have indicated if we suggest that the efforts should rely on co-operation across several countries, or should be made internally by the affected NRAs alone.

<table>
<tr><th>Group of data</th><th>Data type</th><th>Are the NRAs prepared for new requirements?</th><th>What needs to be done by the NRAs</th><th>Co-oper. across NRAs</th></tr>
<tr><td rowspan="2">Road Surfaces</td><td>Pavement Type</td><td>Yes. Categories are based on physical parameters. But some have low coverage.</td><td rowspan="2">Adapt to the coming ROSANNE unified method for classification. Do translations to spectral α- and β-coefficients. Do national investigations to establish average effects, or to underline other conclusions.</td><td>Yes</td></tr>
<tr><td>Pavement Degeneration</td><td>No. Except for a few countries.</td><td>Yes</td></tr>
<tr><td rowspan="6">Noise Barriers</td><td>Barrier Type</td><td colspan="3" rowspan="4">These data types are not investigated specifically in this study because of lack of support in the calculation methods, including CNOSSOS-EU</td></tr>
<tr><td>Barrier Transmission</td></tr>
<tr><td>Barrier Degeneration</td></tr>
<tr><td>Barrier Top</td></tr>
<tr><td>Barrier Dimension</td><td rowspan="2">Yes, for most countries.</td><td rowspan="2">For some countries: Improve precision. Invoke national GIS mapping agencies.</td><td rowspan="2">No</td></tr>
<tr><td>Barrier Position</td></tr>
</table>

	Barrier Absorption	Yes, for most countries.	For some countries: Start collecting absorption data	No
Traffic Data	Vehicle Category	Yes. Although some are still in the adaption process	Keep up the good work.	No
	Speed	Yes for DEN-distribution. But most countries do not use actual speed.	Estimate actual average speed for each vehicle category.	Yes
	Quantity	This is implicitly covered by "vehicle category" above		
Geospatial Data	Topography	Yes. Although a few countries have low resolution	A few countries should increase the topography resolution	No
	Ground Surface	No. Most countries do not have easy access to graded surface data	Considerable efforts are needed to provide data by the 8 classes	Yes
	Road Information	Yes (probably)	Keep the attention up	No
	Building geometry	Yes	Keep attention on building heights	No
	Population per building	Yes, for most countries	For some countries: Work towards specific numbers or more diverse statistics	No
	Population distribution over façades	Yes, for some countries No, for others	Co-operate to find common approaches and practices	Yes
	Building Type	This is implicitly covered by data sets on buildings		

The overall conclusion of this work package is that the NRAs appear to be well prepared for the CNOSSOS-EU requirements limited to the themes of the present study. But for some issues, more work needs to be made by many NRAs before the requirement is fulfilled. This is especially the case for providing data for *pavement degradation*, *ground surfaces* and *population assignment to building façades*. In addition single issues need to be addressed by individual NRAs. Among these we recommend that issues on *pavement type acoustics*, *speed distribution over vehicle categories*, *ground surface* and *population assignment to façades* should be addressed internationally across several NRAs.

We find no prominent regional differences in this study, such as systematic differences between northern and southern Europe. Nevertheless, many of the challenges related to CNOSSOS-EU requirements are similar for several countries. We therefore see an obvious advantage in discussing issues and finding solutions across the NRAs, even though the issue may be of local nature. Any NRA may benefit in co-operating with a neighbour country that already may have solved the issue. This will also contribute to the underlying intention of European harmonisation.

4 References

Hammer E, Steiner S, Dias M, Bühlmann E (2015). Long-term acoustical performance of low noise road surfaces in urban areas in Switzerland. Proceedings of Euronoise, Maastricht, 31 May-3 June, 2015.

Kragh, J. (2008) Road Surfacings - Noise reduction time history. Danish Road Institute Report 161 Copenhagen, 2008

Kragh, J.; Andersen, B.; Pigasse, G. (2013) ACOUSTIC AGEING OF PAVEMENT DVS-DRD joint research programme – Super Silent Traffic, VEJDIREKTORATET, RAPPORT 460, Copenhagen, December 2013

Kragh, J.; Bendtsen, H. (2008) Replacing the top of two-layer porous asphalt at Øster Søgade, proceedings of Euronoise 2008, Paris (July 2008)

Kragh, J.; Andersen, B.; Hofman, R.; Vanvliet WJ; Anfosso-Lédée, F. (2012) Pavement acoustic ageing - noise performance over time, Proceedings of INTERNOISE 2012, New York (19-22 August 2012)

Appendix A
Survey questionnaire

This appendix contains

- the covering letter for the survey questionnaire and
- the complete questionnaire.

The questionnaire was sent accompanied by this covering letter:

Dear ***

Questionnaire about Road Traffic Noise mapping

In the coming round of strategic noise mapping[1] (scheduled for 30 June 2017) European countries will be required to provide extensive mapping of environmental noise according to methodology defined by the CNOSSOS-EU project[2].

Within the DISTANCE project[3], which is carried out by a research consortium comprising BRRC[4], TRL[5], ANAS[6] and SINTEF[7], work is being undertaken to assist in ensuring a uniform and smooth accomplishment of this mapping exercise in the sector of road traffic noise. The project is funded by the European NRA cooperation organisation CEDR[8].

The attached questionnaire survey is a part of the DISTANCE work. It will be answered by selected countries covering all major regions in Europe. The purpose is to collect knowledge for developing road noise mapping strategies that cover issues common to all CEDR members, and at the same time respects challenges specific to certain regions.

---

[1] EC / 2002: Directive 2002/49/EC OF THE EUROPEAN PARLIAMENT AND THE COUNCIL – relating to assessment and management of environmental noise (END)

[2] JRC / 2012: Common Noise Assessment Methods in Europe (CNOSSOS-EU)

[3] CEDR Research project "Developing Innovative Solutions for TrAffic Noise Control in Europe"

[4] Belgian Road Research Laboratory

[5] Transport Research Laboratory (United Kingdom)

[6] ANAS SpA (Italy)

[7] SINTEF – Independent Norwegian research institute

[8] Conference of European Directors of Roads

To be able to evaluate consequences of the new CNOSSOS-EU methodology, we need information about input data for road traffic noise mapping in ***. We therefore invite you to answer the questions below on behalf of your country. They are mainly about availability and use of input data for road noise mapping in your country. The themes of the questionnaire are limited to road surfaces, noise barriers, road traffic information and geospatial data (GIS data sources).

Should it happen that you do not have the expected knowledge to answer the questions, we would encourage you to forward this questionnaire to any other expert who is involved in this kind of noise mapping. Alternatively, let us know, and we will approach another expert.

The answers you provide in this questionnaire will be read and evaluated by the members of the DISTANCE project consortium. Any information identifying you as an individual or organisation will be kept confidential within the consortium, and not distributed to anyone else. But information provided by you about the themes in question may accrue to CEDR and the public through disseminating results from the DISTANCE project.

Please observe that there is no scientific reason for keeping the questionnaire secret. You may freely share your answers with anyone. And, in case you feel the need, you are welcome to discuss the questionnaire with other NRA members of CEDR, and even co-operate in the process of forming the answers. After all, one intention of the project is to prepare the NRA's for a best possible adaption of the CNOSSOS-EU methodology.

If you have any questions or comments regarding this questionnaire survey, please give me a note, and I will be happy to assist in any way.

Yours sincerely,
***

This is the questionnaire:

Questionnaire about Road Traffic Noise mapping

Theme 1: Road surfaces

CNOSSOS-EU requires pavement type corrections as spectral α- and β-coefficients for octave bands from 125 Hz to 4 kHz, where α is the noise surface correction at a reference speed and β gives the deviation factor for other log-relative speeds. This calls for a categorisation method for road segments, for instance based on physical parameters like chipping size, porosity and type of pavement, or visual inspection of the road segments.

Question 1A:

What kind of categorisation of road segments do you use for NRA roads in your country? Please provide supplemental documentation if available.

Question 1B:

How much of the NRA road network in your country is currently categorised in accordance with your categorisation scheme.

- ☐ Practically all road segments
- ☐ Some of the road segments. Please specify approx. percentage ____%
- ☐ None of the road segments are classified

Question 1C:

What efforts do you regard as necessary to fulfil this CNOSSON-EU requirement in your country?

Question 1D:

Most surfaces tend to produce more noise as they degenerate over its lifetime. CNOSSOS-EU requires that member states account for the average effect of this over the representative pavement lifetime.

How does your NRA plan to meet this requirement?

☐ By applying degradation noise corrections based on actual age of the road segments.
☐ By general increasing noise from pavement types associated with degradation effects.
☐ Other method. Please specify:

Theme 2: Noise Barriers

Noise barriers are of particular importance when calculating road noise. Because of their location they normally have significant influence on the sound propagation. The most important parameters are the barrier position, the height, and the sound absorption properties.

Question 2A:

What are your sources of information about noise barrier locations?

☐ General GIS-based digital maps. Approx. ☐ % of the barriers.
☐ Databases / registers maintained by the NRA. Approx. ☐ % of the barriers.
☐ Other sources. Approx. ☐ % of the barriers. Please specify:

Question 2B:

What is the typical uncertainty of the horizontal position the noise barriers?

☐ Better than 0,3 meters
☐ Up to 1 meters
☐ More than 1 meters.

Please specify the uncertainty indicator[9]:

Question 2C:

[9] Use short indicator like "standard deviation", "95 percentile", "maximum" or "unknown"

What is the typical uncertainty of the height of the noise barriers?

- [ ] Better than 0,1 meters
- [ ] Up to 0,3 meters
- [ ] More than 0,3 meters.

Please specify the uncertainty indicator[9]:

Question 2D:

Where relevant, do you take sound absorption into account for noise barriers?

- [ ] No
- [ ] Yes. Please indicate how (data source, absorption coefficient etc.):

Theme 3: Traffic Data

CNOSSOS-EU introduces a requirement for the road traffic to be separated into five distinct vehicle categories. These are:

6. Light vehicles
7. Medium heavy vehicles
8. Heavy vehicles
9. Powered two-wheelers:
   a. Mopeds
   b. More powerful motorcycles
10. New / Future vehicles (optional)

Question 3A:

How do you plan to determine the distribution between the vehicle categories in your country?

- [ ] By specific vehicle counting and/or detailed traffic mix modelling
- [ ] By applying generalized regional or national statistics on vehicle distributions
  - [ ] Separate distributions for different road type
- [ ] By using default category distributions suggested on international level.
  - [ ] Separate distributions for different road type

Please provide shortly additional information about how you plan to adapt to the vehicle categories requirement:

Question 3B:

The traffic quantities shall be expressed for each vehicle category in combination with the day-, evening- and night-time periods.

What day-, evening- and night-time distribution data are you able to provide for your traffic mix?

☐ The full combination of vehicle categories and day/evening/night periods for each road or road type.
☐ Generalized day-, evening- and night-time distributions for each vehicle category and road type combination.
☐ Generalized day-, evening- and night-time distributions for each vehicle category. No separation on road or road type.
☐ Generalized day-, evening- and night-time distributions. No separation on road or road type or vehicle category.
☐ Other. Please specify:

Question 3C:

CNOSSOS-EU requires the use of actual average speed for each vehicle category, with the optional correction for acceleration/deceleration near stop-signs or junctions.

What speed data are you able to provide for your traffic mix?

☐ Average speed values for each vehicle category derived from measurements and/or traffic modelling.
☐ Generalized data for each vehicle category based on regional or national traffic speed statistics.
☐ By applying sign-posted speed
  ☐ with fixed speed reductions for heavy vehicles

☐ Additional corrections for acceleration/deceleration near stop-signs or junctions.

☐ Other. Please specify:

Theme 4: Geospatial Data

Question 4A:

The profile of the terrain is normally described by the variation of ground height over a horizontal plane. Typical sources are elevation contours from digital maps, grid-based elevation models (DEM) or high-resolution raster models from laser scanning by airplane (LIDAR).

What kind of topography data are you able to use (disregarding buildings and screens which are dealt with in later questions)?

☐ High resolution DEM/LIDAR models (grid size <= 10 meters, and typical vertical deviations <= 0,5 meters)
☐ Additional corrections for embankments and cuttings along the noise emitting roads
☐ Low resolution DEM models (grid size <= 30 meters, and typical vertical deviations <= 2 meters)
☐ Height contours from vector-based GIS maps
☐ No topography data is used, we are assuming horizontal ground.
　☐ The ground is actually horizontal, so there is no need for special topography data.

Please provide comments, if any:

Question 4B:

Sound propagation over the terrain is influenced by the acoustic properties of the ground surface. While previous strategic mapping distinguished between two surface types (soft and hard), CNOSSOS-EU specifies 8 ground surface classes evenly spread from very soft (absorbing) surfaces to very hard (reflecting) surfaces. The classes are specified in accordance with new calculation methods like HARMONOISE and Nord 2000. The surface class information is expected to be derived from interpretation of ground related features of GIS maps. Such maps may be provided by national geographical mapping agencies.

What kind of ground surface data do you have for noise calculations?

☐ High resolution maps with surface info compliant with the 8 classes.
☐ Low resolution maps (>=10 meter uncertainty) with surface info compliant with the 8 classes.
☐ Rough surface estimates, like "hard" for water, "half-hard" for urban areas and "soft" for the rest.
☐ Other. Please specify or comment:

Question 4C:

The geometric shape of the road is of special importance, since the road traffic sources are so close connected to the road. In many cases the details about embankments and cuttings are not reflected in the basic topography data, which therefore have to be corrected from road information, provided as supplementary geospatial data.

How do you handle detailed information of the road geometry?

☐ It is included in the topography model and/or the data sets for buildings and screens.
☐ It is derived from road geometry information like centreline trajectory and transversal profile.
☐ It is not handled. Geometries close to the source reflect the general topography uncertainties.
☐ Other. Please specify or comment:

Question 4D:

The gradient of the road influences the vehicles as noise sources.

What kind of information is available for your noise calculations?

☐ Gradients are available specifically for instance as centreline trajectories or longitudinal profiles.
☐ Gradients are calculated from the topography model.
☐ No road gradients are used.
  ☐ Because the ground actually is horizontal.

Question 4E:

Buildings and noise screens have significant influence on sound propagation from road traffic. Noise shielding and sound reflections are important phenomena that depend on the physical position and dimensions of the constructions. It is expected that information is derived from traditional 2½D vector-based GIS maps or more modern 3D object oriented models of the areas.

What kind of data for buildings and screens do you have for noise calculations?

☐ Full 3D model of buildings and screens
☐ Horizontal outlines of building façades and
  ☐ specific height information for each building / screen
  ☐ height information derived from other info like building type or number of floors
  ☐ height information derived from type of area (like "urban city", "scattered village" etc.)
  ☐ height set to a fixed default value
☐ No specific shape and height information. Extensive use of default building shapes and

height.
☐ Other. Please specify or comment:

Question 4F:

To calculate the noise impact it is required that the noise levels on building façades are combined with the number of people living in the building. This is normally done by linking calculated façade noise levels to building type information and census data sources for the community. CNOSSOS-EU provides definitions and methods related to this process.

What kind of population data is available for noise mapping in your country?

☐ The specific number of inhabitants is available
  ☐ for each building.
  ☐ for entities larger than the building (like city blocks, districts etc.).
☐ The number of inhabitants is estimated from population statistics and dwelling floor space.
  ☐ dwelling floor space is known for each building.
  ☐ dwelling floor space is estimated from building base area and number of floors.
☐ Other. Please explain:

Question 4G:

CNOSSOS-EU requires that inhabitants of single dwelling floors are assigned to noise levels along the most exposed façade, and that inhabitants of other buildings are distributed along all façades of the building. This requires that the façade outline is known, preferably in form of vector-based polygon or polyline shapes.

How are your building façade data described?

☐ The actual façade outlines are known in form of vector-based polygons or polylines.
☐ The façade outlines are estimated from other building related data. Please explain how:
