INTER-NOISE 2007
28-31 AUGUST 2007
ISTANBUL, TURKEY

Accuracy implications of using the WG-AEN “Good Practice Guide” toolkits for railways

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ABSTRACT

In support of the WG-AEN, DEFRA has recently commissioned a research project to further extend the range of Toolkits within the Good Practice Guide v2 with quantified accuracy statements. The study has extended the previous research into road traffic noise calculation methods by carrying out Monte Carlo simulations, alongside mapping based error propagation testing, in order to propose quantified decibel accuracy indicators for GPGv2 Toolkits relating to the assessment of railway noise using the RMR Interim Method. This paper sets out an overview of the testing undertaken during the research, and presents the Toolkits with new quantified accuracy statements. The paper will focus on the practical outcomes of the research project in order to inform competent authorities on how the work may be used to deliver cost effective, quality controlled, environmental noise maps to meet the requirements set by the European Noise Directive and noise action plans.

1 INTRODUCTION

1.1 Background

Noise mapping of European cities, along with major road and rail links between cities, is currently being undertaken across all 25 countries within the EU in response to the requirements of European Commission Directive 2002/49/EC [1], relating to the assessment and management of environmental noise, referred to as the Environmental Noise Directive (END). The Directive requires there to be an assessment of environmental noise exposure,

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through noise mapping. The results of the noise mapping are to be used as a basis for the adoption of noise action plans, to help prevent and reduce environmental noise, where required, and to aim at providing a basis for the development of community measures to reduce noise.

The EC Working Group on the Assessment of Exposure to Noise (WG-AEN) has developed practical guidance on some of the challenges of producing noise maps over large areas within the Position Paper "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure" (GPG) [2]. The GPG sets out a series of Toolkits which can be used by Member States when fulfilling the requirements of the END. The Toolkits within the GPG are designed to provide guidance on the potential steps to be taken, or assumptions to be made, when the datasets available fall short of the coverage or detail required for the large scale wide area noise mapping required by the END.

1.2 Previous research

In 2004 Defra let a research contract to Hepworth Acoustics, DGMR and Acustinet to investigate how the quality of input data used for road traffic noise modelling could affect the reliability of the noise levels calculated. It was found to be the first significant investigation into input data accuracy requirements in the context of environmental noise mapping, and led to the development of the first model of uncertainty within the modelling process.

The research delivered the following results, and has been reported previously [3],[4],[5]:

- First complete model of uncertainty within the noise modelling process;
- Six new GPG Toolkits, subsequently incorporated within GPGv2;
- Quantified accuracy statements for 12 GPGv2 Toolkits in relation to assessment of noise using XPS 31-133 Interim Method;
- Quantified accuracy statements for 12 GPGv2 Toolkits in relation to assessment of noise using UK adapted CRTN method; and
- Practical guidance on the assessment of uncertainty within input datasets and their impact upon the uncertainty within the resultant assessed road noise levels.

1.3 This research project

In 2006 Defra let a follow up research project to undertake an equivalent investigation into the assessment of noise from railways. The re search project was awarded to the original project team, augmented by the addition of Acustica and railway acoustics specialists from DeltaRail.

The key objectives of the project may be summarised as follows:

- To extend and build upon the work carried out in the original Research Project NANR 93, "WG-AEN's Good Practice Guide & the Implications For Acoustic Accuracy";
- To quantify the accuracy symbols within the GPG v2 when Toolkits 8, 9, 12, 13, 15 and 16 are used in conjunction with the UK Calculation of Railway Noise, 1995, (CRN) and the recommended adapted Interim Method for the assessment of Railway Noise based upon the Netherlands method RMR 1996 (RMR Interim);
- Provide additional practical guidance on any issues concerning the application of the Toolkits 8, 9, 12, 13, 15 and 16 in the GPG v2 relating to railway noise mapping that are uncovered whilst undertaking the study; and
- To provide practical guidance on the consequences of the accuracy of input datasets that are suitable for use with CRN and RMR Interim for noise mapping purposes, through the use of error propagation techniques.

2 UNCERTAINTY IN NOISE MAPPING

The accuracy study focused on how the uncertainty in the calculated result in decibels may be related to uncertainty, errors, or assumptions in the input parameters. A study of this nature is generally referred to as an “error propagation” analysis.

To understand how this form of study is useful in noise mapping, and also how it may help to build up an understanding of the complete picture, it is instructive to consider the work by Isukapalli and Georgopoulos [6] who stated that there are normally four stages involved in the uncertainty analysis of a model:

- estimation of uncertainties in model inputs and parameters (characterisation of input uncertainties);
- estimation of the uncertainty in model outputs resulting from the uncertainty in model inputs and model parameters (uncertainty propagation or sensitivity);
- characterisation of uncertainties associated with different model structures and model formulations (characterisation of model uncertainty); and
- characterisation of the uncertainties in model predictions resulting from uncertainties in the evaluation data (uncertainty of evaluation data).

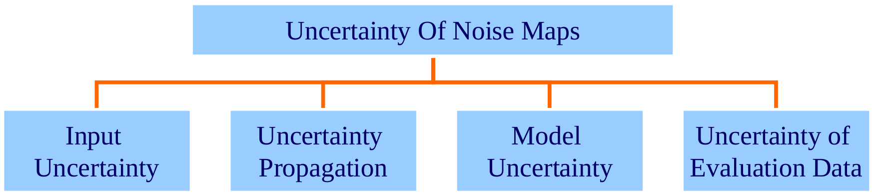


Figure 1: Four components determining the uncertainty of noise maps

2.1 Uncertainty Propagation or Sensitivity

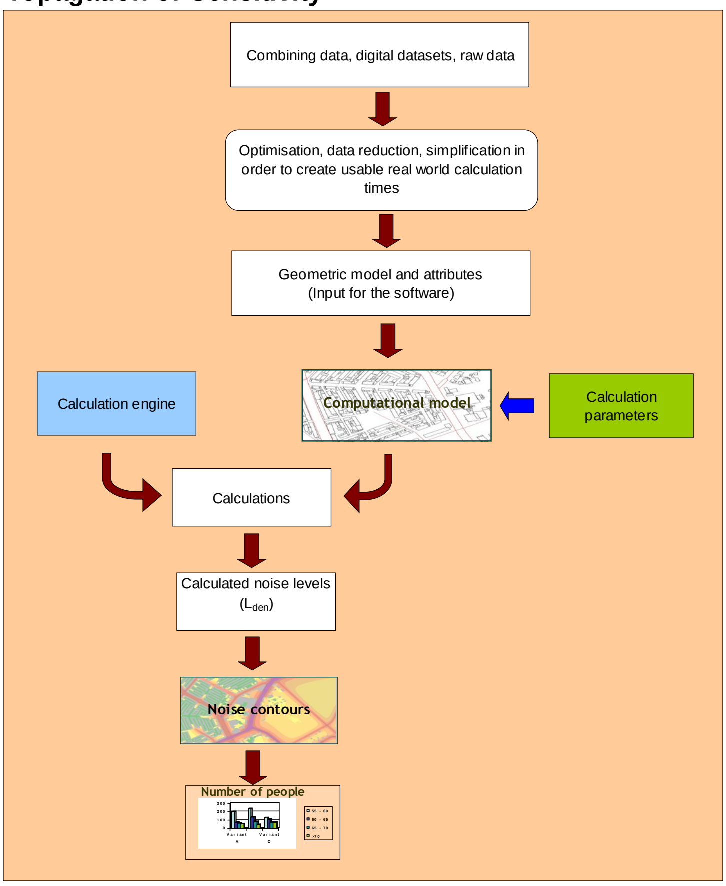


Figure 2: Error propagation uncertainty flow chart.

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.

The work within these two research projects was centred 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 results were used to present quantified accuracy statements for 12 GPGv2 Toolkits for the XPS 31-133 Interim Method, and eight GPGv2 Toolkits for the RMR Interim Method. In Figure 2 below, a flow chart is presented showing how error propagation uncertainty is introduced into the noise mapping. The analysis was undertaken in two forms to provide results to inform two types of guidance.

- Using step changes to the input data type and quality in accordance with the guidance set out in the GPG Toolkits;
- An analysis of sensitivity to variation in the input attributes for both RMR Interim [7] and CRN [8], in order to assess a ranking order for input data quality, and develop a practical specification for noise mapping datasets.

3 RMR INTERIM FOR NOISE MAPPING

Under the requirements of the END a Member State is able to choose either the recommended Interim Methods, or existing national methods, for the assessment of noise.

Annex II 2.2 of Directive 2002/49/EC covers “Assessment Methods for the Noise Indicators” the recommended interim calculation method for railway noise RMR 1996 [7].

The Official Journal of the European Union (OJEU) 6 August 2003 contained Commission Recommendation “concerning the guidelines on the revised interim computation methods for industrial noise, aircraft noise, road traffic noise and railway noise, and related emission data”.

Prior to the publication of the OJEU notice, there was issued the final report from EC Contract B4-3040/2001/329750/MAR/C1 [9]. It is very important to note that the Final Report from the Wölfel project does not contain the same recommended adaptations as the OJEU notice 2003/613/EC.

The final report does, however, provide the only accessible version of RMR 1996 for non-Dutch speakers, via the edited non-contextual translation into English, see WP 3.2.1 of the Wölfel research project EC Contract B4-3040/2001/329750/MAR/C1. Unfortunately the project team are not aware of a complete, unedited, translation of RMR 1996 which may be recommended to Member States.

The technical specification for the railway noise calculation method investigated within this research project is described as:

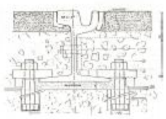
- ‘Reken- en Meetvoorschrift Railverkeerslawaai '96, Ministerie Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 20 November 1996’;
- Plus the Commission Recommended Adaptation from 2003/613/EC.

This method is referred to throughout the project reports as “RMR Interim” in an attempt to distinguish it from the original RMR 1996, or the more recent draft versions from RMVR 2002 and RMVR 2004 or the published RMR 2006.

4 GPG TOOLKITS WITH QUANTIFIED ERRORS FOR RMR INTERIM

4.1 Toolkit 8: Sound power level of trams and light-rail vehicles

Tool 8.1: Corrections for Squeal noise and Impulsive noise			
Method	complexity	accuracy	cost
Observation for a representative, dry, period for curves with a radius < 100 m No squeal noise: no correction Squeal noise: correction on the source emission of 12 dB(A). This is a physical correction on the regular source emission, based on experience. The correction to be applied over the section of the curve where squeal noise occurs.		> 5 dB	
Where rail joints occur: No impulsive noise: no correction Impulsive noise correction on the source emission of +3 dB(A) for the line source 30 m before and after the rail joint.		3 dB	

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)		3 dB	

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})		2 dB	

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 used rail constructions and the representative rail roughness.		< 0.5 dB	
Measure the acoustical sound power level per unit for squeal noise and impulsive noise on the used rail network as a function of speed and for the different used rail constructions. (Measurements of squeal noise are very complicated and they take a long time) [1]		< 0.5 dB	
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 9.2 For both rail constructions and for no regular maintenance of the rail roughness: make a correction of +2 dB		> 5 dB	

[1] Note: The <0.5dB accuracy statement assigned pertains to the level of modelling error introduced by using this approach; it does not consider the uncertainty within the measurement process itself, which should be determined during the measurement exercise.

4.2 Toolkit 9: Train (or Tram) Speed

Toolkit 9: Train (or tram) speed			
Method	complexity	accuracy	cost
Reliable train speeds are **available from the owner of the tracks**		< 0.5 dB	
Reliable train speeds are **available from the operators of the trains**		< 0.5 dB	
Measure train speeds		< 0.5 dB	
Use timetables and distances to calculate an average speed (may not be possible for freight trains)		2 dB	
Take the minimum of the following two values: • maximum train speed • maximum track speed		4 dB	

4.3 Toolkit 11: Ground Elevation Close to Source

Tool 11.1: GPS height of a road			
Method	complexity	accuracy	cost
The rail height can be determined by measurement[1]. This can be combined with an estimation of global ground height to determine the relative 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[1] or alternatively by visual estimation of the height above local terrain.		< 0.5 dB	

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

Tool 11.2: Cross sections			
Method	complexity	accuracy	cost
If cross sections from a railway are available, the relative source 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 source 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 railway is given in the table below:		4 dB	

crossing item	height
Railway	8.0 m
major road	6.0 m
local road	4.0 m

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

4.4 Toolkit 12: Cuttings and embankments

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
<u>Approach for cuttings:</u> 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 area.		Determined by 12.1 or 12.3 and Toolkit 11	
<u>Approach for embankments:</u> Digitise contour lines along the top of the embankment, on both sides, to model the railway area. Digitise contour lines along the bottom of the embankment, on both sides, to model the nearby area.		Determined by 12.1 or 12.3 and Toolkit 11	

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		1 dB	
Estimate the height from the site visit **then digitise** the **position** from **aerial photos:** Continue with tool 12.2		3 dB	
Estimate the **position and height** from the site visit: Continue with tool 12.2		3 dB	
Ignore cuttings if no relevant sources are located in these cuttings.		1 dB	

4.5 Toolkit 13: Ground surface type

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.	◇	2 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.	△	3 dB	△

Tool 13.3: No data available

Method	complexity	accuracy	cost
Use reflective ground everywhere as a worst-case default	△	> 5 dB	△

4.6 Toolkit 14: Barrier Heights near Railways

Tool 14.1 Height relative to railway

Method	complexity	accuracy	cost
Subtract the height of a railway from the ground height at the barrier to get the height of the barrier above railway level.	◇	< 0.5 dB	◇
Derive the height of a barrier from a drawing with a cross section.	◇	1 dB	◇

Tool 14.2: Visual estimation of height

Method	complexity	accuracy	cost
Visual inspection of the barrier height relative to the railhead (preferably from trackside)	◇	2 dB	◇
Divide barriers into classes and take the default barrier height from the classification. <u>Example:</u>	△	4 dB	△

class	height
low	1.5 m
medium	3.0 m
high	6.0 m

4.7 Toolkit 15: Building heights

Tool 15.1: Number of storeys available

Method	complexity	accuracy	cost
Multiply number of storeys with the average storey height (e.g. 3 m)	△	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[3]	◇	> 5 dB	△
Use a **default height** for all buildings (e.g. 8 m)	△	> 5 dB	△

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

4.8 Toolkit 16: Sound absorption coefficients for buildings and barriers

Toolkit 16: Sound absorption coefficients α_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:			2 dB	
Structure	**Suggested α_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			

5 GUIDELINES

Table 1 presents a general guideline of the accuracy range of the input parameters for different decibel uncertainty groups in the total train emission based on the results of the analysis. It is important to realise that the stated accuracy requirements are calculated independently. A certain accuracy level for one parameter is only valid if the other parameters are 100% accurate.

Table 1: Accuracy of the input parameter required for different uncertainty groups in the train emissions for breaking and non-braking trains.

	Source height	**Group A <0.5dB(A)**	**Group B 0.5-1 dB(A)**	**Group C 1-2 dB(A)**	**Group D 2-5 dB(A)**	**Group E >5dB(A)**
Train Speed (V)	0.0 m[2]	(5-11)%<	(5-11)-(10-22)%	(10-22)-(20-42)%	(20-42)-(50-98)%	>(50-98)%
	0.5 m[2]	(5-11)%<	(5-11)-(10-22)%	(10-22)-(20-42)%	(20-42)-(50-98)%	>(50-98)%
	2.0 m[1]	5%<	5-9%	9-18%	18-43%	>43%
	4.0 m[1]	5%<	5-10%	10-19%	19-46%	>46%
	5.0 m[1]	4%<	4-8%	8-16%	16-39%	>39%
Train Flow (Q)	0.0 m	10%<	10-18%	18-35%	35-78%	>78%
	0.5 m	10%<	10-18%	18-35%	35-78%	>78%
	2.0 m[1]	10%<	10-18%	18-35%	35-78%	>78%
	4.0 m[1]	10%<	10-18%	18-35%	35-78%	>78%
	5.0 m[1]	10%<	10-18%	18-35%	35-78%	>78%

Note 1: Apply to train category 9 only.

Note 2: For a given Group, low values of speed have accuracy requirements towards the lower end of the range presented, and high values of speed may have uncertainties towards the upper end of the range presented.

Table 2 presents the accuracy range of the input parameters for different error groups in the total emission level in the case of simultaneous uncertainties in the input parameters. It is important to realise that the stated accuracy requirements are calculated independently.

Table 2: Accuracy range of the input parameter for different uncertainty groups in the train emission in the case of simultaneous uncertainties in the input parameters.

	Source height	**Group A <0.5dB(A)**	**Group B 0.5-1 dB(A)**	**Group C 1-2 dB(A)**	**Group D 2-5 dB(A)**	**Group E >5dB(A)**
Comb error (Vnbr, Vbr, Qnbr, Qbr)	0.0 m[2]	(4-8)%<	(4-8)-(9-15)%	(9-15)–(18-28)%	(18-28)-(44-63)%	>(44-63)%
	0.5 m[2]	(4-8)%<	(4-8)-(9-	(9-15)–(18-	(18-28)-	>(44-63)%

			15)%	28)%	(44-63)%	
	2.0 m[1]	4% <	4-9%	9-17%	17-41%	>41%
	4.0 m[1]	5% <	5-9%	9-18%	18-44%	>44%
	5.0 m[1]	4% <	4-8%	8-15%	15-37%	>37%

Note 1: Apply to train category 9 only.

Note 2: For a given Group, low values of speed have accuracy requirements towards the lower end of the range presented, and high values of speed may have uncertainties towards the upper end of the range presented.

Table 3, 4 and 5 below set 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 3: RMR Interim Railway source geometry

	Factor	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
Source	Track Type	No error, sections <5m	No error, sections <20m	No error, sections <50m	No error, sections <500m	No info (default type)
	Railway centreline (Vertical)	<0.5m	>0.5m - <1.0m	>1.0m - <2.0m	>2.0m - <5.0m	>5.0m
	Railway centreline (Horizontal)	<1.5m	>1.5m - <4.0m	>4.0m - <8.0m	>8.0m - <15m	>15m

Table 4: RMR Interim Modelling Geometry

	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)	<0.5m	>0.5m – <1.0m	>1.0m - <3.0m	>3.0m - <10m	>10m
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	Use absorption classes	Use absorption classes	Use absorption classes	No info (reflective)	No info (reflective)
Barriers	Barriers (Vertical re road surface)	<0.5m	<0.5m	>0.5m - <1.0m	>1.0m - <2.0m	>2.0m
	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	>0.5m - <1.0m	>1.0m - <2.0m	>2.0m
	Barrier Minimum Length (m)	<10m	>10m - <25m	>25m - <40m	>40m - <100m	>100m

	Absorption coefficient	Use absorption classes	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

Table 5: Interim Railway Traffic Data Attributes

	Factor	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
Source	Train type classification	No error; use measured Lw outside NL	No error; use most similar type outside NL	No error; use most similar type outside NL	No info (choose single average class)	No info (choose single average class)
	Train Speed	(5-11)%<	(5-11)-(10-22)%	(10-22)-(20-42)%	(20-42)-(50-98)%	>(50-98)%
	Train Flow	10%<	10-18%	18-35%	35-78%	>78%
	Flow Type (braking gear activated)	No error				

Note: It should be noted that this testing has not considered the likely situation when non-Dutch vehicles have noise emissions somewhat different from Dutch vehicles with a similar technical description. There are many factors, including wheel/rail roughness, which may influence the emissions from rail vehicles across the EU which were outside the scope of this research.

6 CONCLUSIONS

These two research projects have investigated the link between the quality of input data required to undertake an assessment of road and railway noise impact, and the quality of the noise level results obtained across a noise map. By using a combination of technical approaches, the wide range of input data required has been investigated, and an understanding developed on how each affects the uncertainty within the resultant calculated noise level. This understanding has been translated into a number of GPG Toolkits, as quantified accuracy statements associated with each Toolkit option, and also as a series of practical recommendations for noise mapping bodies undertaking assessments for the Directive [10].

The research has concluded that, in general, many of the data elements shared between road and railway assessment methods, such as 3D terrain models, barriers, cuttings and embankments, need to be more carefully identified and modelled for railway projects than for road projects with agglomerations, for an equivalent level of uncertainty in the noise level calculated. It has also concluded that the correct assessment of emitted noise levels from railway lines provides a more complex challenge than for road traffic, predominantly because of the way in which the assessment methods have been designed. Clear identification of railway vehicles plays a central role in the methodologies, and requires detailed knowledge of vehicle construction in order to minimise the uncertainty in the results.

These research projects have extended current knowledge and understanding of uncertainty in the assessment of noise. The approach taken for these studies provides guidance on the approach that will be necessary to understand error propagation in other current and future noise assessment methodologies. The results delivered have focused towards the practical delivery of noise maps for the Directive, and will provide information for Defra and the other EU Member States. This will enable the limited budgets available for the development of input datasets to be focused on those elements of the noise model which will have the greatest impact upon the quality of the results, and help to avoid expenditure on unnecessary information. This will help to provide a more robust evidence base for decisions regarding management of environmental noise.

The major problem with testing uncertainty in spatial datasets is the time it takes to develop a large number of input datasets with spatial variations, and the extensive calculation time required to run each of these models and analyse the results. Within areas such as climate change, ground water analysis and air pollution, the way around these barriers has been to use advanced techniques to analyse the statistical spread of input variation for each of the input datasets, and from this develop a subset of models which describe the statistical variation expected. Methods such as stochastic surface modelling or fuzzy set theory may be appropriate, as may engaging with experts in the statistical analysis, such as those from the Applied Statistics group at the Joint Research Centre (JRC) of the European Commission (Ispra, VA, Italy). Working with a noise mapping software developer the uncertainty assessment could even be handled within the main calculation core of the software. This would provide considerable gains in speed and flexibility.

The importance of this area of research could be seen to warrant a noise equivalent to the EU ARTEMIS project looking into uncertainty in air pollution systems, as well as a significant extension of the work currently undertaken to investigate the Harmonoise/Imagine methodology [11], [12].

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