Develop and Implement
Harmonised Noise Assessment Methods

Process Applied to Establish CNOSSOS-EU/National Method Equivalence for Road Source data

General Approach

In order to enable data and knowledge relevant to existing national methods to be applied to the CNOSSOS-EU approach, it is necessary to identify how input data used in existing national method may be represented in CNOSSOS-EU.

Preferably the MS would establish, either from records or new measurements, relevant data in the CNOSSOS-EU database format. However, as an interim approach, a match between a selection of national method data categories and the 'default' or sample data examples within the input database files, "CNOSSOS_Road_Surface" and "CNOSSOS_Road_Params" ("the database"), for the road traffic source emission software module have been established as follows.

In several instances the national methods use calculations of overall dB(A) emission levels, often as an SPL at a reference distance from the virtual source(s) location. As CNOSSOS-EU calculates an octave band sound power level emission for road traffic sources, and it does not yet have a definitive selection of propagation method with which to calculate the SPL at the reference distance, the selections made to translate existing data relevant to a national method into the CNOSSOS-EU databases has been based around the concept of providing similar responses to changes in input data, rather than demonstrable ability to calculate the same emission level at the reference location, as this was not possible at the time. This approach should provide sufficient clarity in the context of strategic noise mapping where hot spots are to be identified, and differences between road surfaces, for example, will be similar to the existing national method.

It is considered unrealistic to expect CNOSSOS-EU to calculate the same noise level in all locations within a model as an existing national method, as there are many detailed differences in the calculation processes, relating to both the source emission and propagation aspects. Should any Member States which require a more accurate translation from an existing national method to CNOSSOS-EU, relevant studies would be possible after the selection of the CNOSSOS-EU propagation method, and new entries for the road source input database tables may be generated from measurement studies following the approaches outlined in the Annexes of this report.

Calculation of road traffic noise emission

The calculation of noise emitted by road traffic under CNOSSOS-EU is documented in Chapter III of the JRC Reference Report: Common Noise Assessment Methods in Europe (CNOSSOS-EU), 2012. In the context of this project an open source implementation of the method has been developed in software as "CNOSSOS_ROADNOISE_DLL.dll", 23/04/2014, which may be called using the console "CNOSSOS_DLL_CONSOLE.exe". The DLL read three input files setting out specific details for the road segment being calculated:

- CNOSSOS_Road_Input.xml
  - Input data for the road segment being calculated
- CNOSSOS_Road_Params.xml
  - All look-up tables, except the road surfaces, needed for the calculation of the emission of road noise
- CNOSSOS_Road_Surfaces.xml
  - Look-up table for the road surfaces, needed for the calculation of the emission of road noise

The "Params" and "Surfaces" look-up tables are database tables which would normally be considered static within any project, Member State or even across the EU. Phase B of the CNOSSOS-EU process set out within the JRC Reference Report envisages WG/DT 7 "CNOSSOS-EU database" would be responsible for management of these look up tables in the longer term. The "input" data will be different for each unique set of attributes assigned to a road segment within a project model. These would be the result of the specific local data within each city.

CNOSSOS_Road_Input

The user input information required for each segment is:

- Average Temperature (^{o}C)
- Slope (%)
- Road surface type – reference to CNOSSOS_Road_Surfaces look-up table
- Months per year vehicles equipped with studded tyres
- Distance to junction
- Type of junction
- Per vehicles category 1 to 5 – reference to Road_Params look-up table
  - Vehicle flow
  - Velocity (km/h)
  - Fraction of vehicles equipped with studded tyres

It is considered that each of these inputs is either unique to CNOSSOS-EU, or a direct one-to-one relationship with existing national methods, such as vehicle flow, velocity, slope etc. It is therefore considered not necessary to establish any look-up tables to translate existing model data into CNOSSOS-EU as the data may be used without adaptation.

CNOSSOS_Road_Params

The road parameters look-up contains the following database tables:

- Reference speed
- Source height
- Reference temperature
- Vehicle definitions:
  - Cat 1 – light vehicles
  - Cat 2 – Light trucks
  - Cat 3 - Heavy trucks
  - Cat 4b – Light mopeds

    - Cat 4b – Motorbikes and quad bikes
    - Cat 5 – Open category
    - For each vehicles category the following parameters are defined:
        - Description
        - Rolling noise – active or inactive
        - Propulsion noise – active or inactive
        - Studded tyres – used or not used
        - a i and b i coefficients if studded tyres are calculated
        - K surface - generic coefficient K per octave to calculate the effect of air temperature on rolling noise correction
- Gradient calculation
    - Calculated per vehicle category
- Emission coefficients
    - coefficients AR,i,m and BR,i,m for rolling noise
    - coefficients AP,i,m and BP,i,m for propulsion noise
- Speed variations
    - Coefficients Cr,k en Cp,k for acceleration and deceleration effect per vehicle category, per junction type

It is considered that the reference speed, source height, reference temperature, gradient calculation and speed variations near junctions are an inherent part of the CNOSSOS-EU methodology, and therefore are not to be adapted. For this reason no look-up tables for translation of existing data are proposed.

In regard to the adaptation of noise models for use with existing national methods, there are existing national methods with more or fewer road vehicles categories than CNOSSOS-EU. In these cases look-up tables are proposed below which provide a means to adapt existing noise mapping models to the CNOSSOS-EU method, and which will provide similar results in the context of strategic noise mapping and the identification of hot spots for action planning. The main issue is related to the two heavy vehicles categories in CNOSSOS-EU and their relationship to the single heavy vehicles categories in many existing national methods. At present the proposal is to split the existing heavy vehicles flow from the national methods equally between the two categories in CNOSSOS-EU.

Member States which require a more accurate translation from an existing national method to CNOSSOS-EU may establish more detailed guidance on the assignment of the heavy vehicles from an existing national method into CNOSSOS-EU, possibly based upon local, regional or national statistics derived from detailed traffic counts, vehicle registration numbers or mileage covered by different classes of commercial vehicles.

It may be considered suitable to consider the discussion in Annex A of the Harmonoise report "*Work Package 1.1: Vehicle Categories for Description of Noise Sources*",2003, where it is considered possible to change the proportional split of light and heavy commercial vehicles, dependent upon the road classification, as shown in Table 1.

Table 1: Harmonoise WP1.1 example of default ration split for heavy vehicles

Type of road	Default proportion if no distinction made[1]		Default proportion if distinction is made	
	Cat. 2	Cat. 3	Cat. 2	Cat. 3
Major road with high proportion of heavy transit traffic (e.g. E-type motorways)	40 %	60 %	10 %	90 %
Urban streets (excluding streets carrying a substantial through traffic)	40 %	60 %	90 %	10 %
All other roads (roads and streets not identified as belonging to the types above)	40 %	60 %	40 %	60 %

[1] This case assumes that there is no distinction made between various road types; implying that the simplified default values of the table on the previous page are used.

The existing vehicle categories currently have a one-to-one relationship with the *A* and *B* values for rolling noise, propulsion noise, or rolling noise if studded tyres are used. It is considered that these are part of the CNOSSOS-EU methodology and do provide a good representation of the vehicle fleets in evidence across the EU. The values were derived from large databases of spectra, and come from the extensive work undertaken through the development of the Nord2000, Harmonoise and IMAGINE projects, as well as the technical work undertaken by the Member States within the CNOSSOS-EU WG/DT 2. The various factors are based upon a vehicle fleet for which the characteristics correspond to the values found for the European average as described in IMAGINE report D11, namely:

- 187mm tyre width for Category 1;
- 19% diesel for Category 1;
- 10.5% delivery vans in Category 1;
- 4 axles for Category 3; and
- 35% IRESS (illegal replacement exhaust silencing systems) for Category 4, 1% for other Categories 1 to 3.

Despite this background, it is accepted that there may be certain situations where project or MS specific data may be considered relevant, such as a significant variation away from the average European fleet described in IMAGINE, in which case it is proposed that where necessary an additional vehicle category is defined, which references additional values added to the emission coefficients data table. To establish a new vehicle category the following information would be required:

- Category ID number (5 or above)
- Description
- Rolling noise – active or inactive
- Propulsion noise – active or inactive
- Studded tyres – used or not used
- *A* and *B* coefficients if studded tyres are calculated

- K surface - generic coefficient K per octave to calculate the effect of air temperature on rolling noise correction
- Gradient calculation
- Emission coefficients
    - o coefficients AR,i,m and BR,i,m for rolling noise
    - o coefficients AP,i,m and BP,i,m for propulsion noise
- Speed variations
    - o Coefficients Cr,k en Cp,k for acceleration and deceleration effect per junction type

Where appropriate it may be possible to use values from existing definitions. Some information on how to derive new values for the input tables is provided in the Annex 2 to this report.

CNOSSOS_Road_Surfaces

The CNOSSOS-EU road calculation model assumes a virtual reference road surface,
consisting of an average of dense asphalt concrete 0/11 and stone mastic asphalt 0/11, between 2 and 7 years old and in a representative maintenance condition.

The ΔL WR,road,i,m correction coefficient accounts for the effect on rolling noise of a road surface with different acoustic properties from the virtual reference surface. It includes both the effect on propagation and on generation. Road surface coefficients αi,m and βm are required for the calculation of the correction factors. αi,m is the spectral correction in dB at reference speed v ref for category m (1, 2 or 3) and spectral band i (octave band from 125 to 4000 Hz). Bm is the speed effect on rolling noise reduction. Although this coefficient is in principle frequency-dependent, no spectral data are available in the literature and a constant value is assumed in this method. In the ca se of a porous road surface the αi,m coefficient will decrease the propulsion noise, but dense surfaces will not increase it.

The road surfaces look-up contains the 14 road surface coefficients αi,m and βm from the current Dutch road traffic calculation method. These provide a range of road surfaces considered typical for the purpose of strategic noise mapping, from quiet road surfaces, through standard mastic asphalt to concrete and cobbles. In the context of the adaptation of existing national methods to CNOSSOS-EU a look-up table has been provided for each existing national method which indicates which of the 14 Dutch road surfaces in the database would provide a similar relative effect to the surface in the national method. As elsewhere, the focus has been on attempting to provide a similar step change in emissions in CNOSSOS-EU to the national method, in support of strategic noise mapping and the identification of hot spots. Member States which require a more accurate translation from an existing national method to CNOSSOS-EU may establish additional entries in the road surface database table based upon measurement information. The relevant procedures are outlined in the Annex 1 of this report.

NMPB 96 EU Recommended Interim Method

NMPB 96 EU Interim CNOSSOS Equivalence "Based on 'Guide du bruit des transports terrestres, fascicule prévision des niveaux sonores, CETUR 1980', Commission Recommendation 2003/613/EC and AR-INTERIM-CM "WP 3.1.2: Road traffic noise - Noise emission: databases"

Notes:

1. The lookup tables below are set out in order to provide data migration from an NMPB 96 EU Interim model to a CNOSSOS-EU model;

2. The noise emission level of a vehicle is characterised by the maximum pass-by sound level at 7.5m from the centreline, until the CNOSSOS-EU propagation method is selected it is not possible to directly assess the numerical equivalence of the CNOSSOS road source with NMPB 96 EC Interim. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. The elementary noise source is located 0.5m above the ground. There has been no attempt to correct the emission for the difference in emission height compared to CNOSSOS-EU;

4. The single HGV class in NMPB 96 EU Interim has a total laden weight of at least 3500 kg, the same as the HGV classes in CNOSSOS-EU. By default it has been split 50/50 amongst the 2 HGV classes in CNOSSOS-EU, where more detailed traffic flow data is available this ratio should be adapted to each project area;

5. The road surface type corrections are taken from Commission recommendation 2003/613/EC which have been match across to the Dutch road surface types of similar physical construction with similar level difference between the surfaces. If this level of detail is required additional surface types could be added;

6. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

NMPB 96 EU Interim Vehicle class	CNOSSOS vehicle
No of Light Vehicles	1
50% of No. of HGVs	2
50% of No. of HGVs	3
NMPB 96 EU Interim Road surface	CNOSSOS road surface
Rough texture paving stones (+6)	NL11
Smooth texture paving stones (+3)	NL10
Cement concrete and corrugated asphalt (+2)	NL08
Smooth asphalt (0dB)	NL05
Porous surface (-1 to -3 dependent upon speed)	NL13

CRTN CNOSSOS Equivalence (UK)

Based on Department for Transport Publication "Calculation of Road traffic Noise 1998"

Notes:

1. The lookup tables below are set out in order to provide data migration from a CRTN model to a CNOSSOS-EU model;

2. The Basic Noise Level in CRTN is assessed at 10m from the emission line; until the CNOSSOS-EU propagation method is selected it is not possible to directly assess the numerical equivalence of the CNOSSOS road source with CRTN. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. CRTN uses a total traffic volume and %HGV, this would need to be pre-processed to calculate the number of light vehicles, and number of heavy vehicles per period, e.g. "No. of HGVs" = "Total flow" x %HGV, and then "No. of light vehicles" = "Total flow" - "No. of HGVs";

4. In CRTN the HGV class is defined as those with unladen weight exceeding 1525kg, however it is now widely accepted in the UK that this should be considered as commercial vehicles above 2500kg. The CNOSSOS-EU HGV classes are above 3500 kg, this difference has been ignored in the context of these recommendations. The single HGV class in CRTN has by default been split 50/50 amongst the 2 HGV classes in CNOSSOS-EU, where more detailed traffic flow data is available this ratio should be adapted to each project area;

5. The three road surface types have been matched across to three of the Dutch road surface types of similar physical construction; there is no equivalent in CNOSSOS-EU for the texture depth attribute in CRTN. If this level of detail is required additional surface types could be added;

6. CRTN 1988 calculates overall $L_{A10,18hr}$ noise levels, CNOSSOS-EU calculates octave band L_{Aeq} noise levels;

7. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

CRTN Vehicle class	CNOSSOS vehicle
No of Light Vehicles	1
50% of No. of HGVs	2
50% of No. of HGVs	3
CRTN Road surface	**CNOSSOS road surface**
Pervious macadam	NL13
Impervious macadam	NL05
Concrete	NL08

Nord2000 Road CNOSSOS Equivalence (Nordic)

Based on "User's Guide Nord2000 Road", May 2006

Notes:

1. The lookup tables below are set out in order to provide data migration from a Nord2000 Road model to a CNOSSOS-EU model;

2. At present each Nord2000 vehicle sub-class is mapped across to the same CNOSSOS-EU vehicle class with single values for the emission coefficients Ar, Br, Ap and Bp. If more detailed equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. The eight road surface types have been matched across to eight of the Dutch road surface types of similar physical construction. If additional level of detail is required additional surface types could be added to the CNOSSOS database;

4. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

Nord2000 Road vehicle class					CNOSSOS vehicle	
Light	1a				1	
	1b				1	
	1c				1	
Medium	2a				2	
heavy	2b				2	
	2c				2	
	2d				2	
	2e				2	
Heavy	3a				3	
	3b				3	
	3c				3	
	3d				3	
	3e				3	
	3f				3	
Other	4a				3	
heavy	4b				3	
two-	5a				4a	
wheelers	5b				4b	
Nord2000 Road surface					CNOSSOS road surface	
DAC 11	Asphalt				NL05	
PAC 8	Porous asphalt 8mm				NL01	
PAC 11	Porous asphalt 11mm				NL02	
PAC 16	Porous asphalt 16mm				NL03	
CCB lo	Concrete, longitudinally brished				NL06	
CCB tr	Concrete, transversely brushed				NL09	
PS even	Even pavement stones				NL10	
PS uneven	Uneven pavement stones				NL11	

RLS90 2006 (Germany)

Based on "Richtlinie für den Lärmschutz an Straßen, August 1990" plus road surface updates, and AR-INTERIM-CM "WP 3.1.2: Road traffic noise - Noise emission: databases"

Notes:

1. The lookup tables below are set out in order to provide data migration from an RLS90 model to a CNOSSOS-EU model;

2. The reference distance is 25m to the centre of the road lane and 4m above the road plane. Until the CNOSSOS-EU propagation method is selected it is not possible to directly assess the numerical equivalence of the CNOSSOS road source with RLS90. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. The elementary noise source is located 0.5m above the ground. There has been no attempt to correct the emission for the difference in emission height compared to CNOSSOS-EU;

4. In RLS90 the HGV class is defined as those with weight exceeding 2800 kg. The CNOSSOS-EU HGV classes are above 3500 kg, this difference has been ignored in the context of these recommendations. The single HGV class in RLS90 has by default been split 50/50 amongst the 2 HGV classes in CNOSSOS-EU, where more detailed traffic flow data is available this ratio should be adapted to each project area;

5. The four road surface types from RLS90, plus the low noise road surfaces in the updates, have been matched across to Dutch road surface types of similar physical construction which provide a similar step change in levels. The speed depended aspect of C_{surf} in RLS90 may not be accurately reflected in CNOSSOS. If this level of detail is required additional surface types could be added

6. RLS90 calculates overall L_{Aeq} noise levels, CNOSSOS-EU calculates octave band L_{Aeq} noise levels;

7. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

RLS90 Vehicle class	CNOSSOS vehicle
No of Light Vehicles	1
50% of No. of HGVs	2
50% of No. of HGVs	3
RLS90 Road surface	CNOSSOS road surface
Porous asphalt >15% pores type 0/8 (-5)	NL03
Porous asphalt >15% pores type 0/11 (-4)	NL02
Concrete with burlap cloth (smooth) (-2)	NL13
Asphalt concrete without grit (-2)	NL13
Non grooved asphalts, concrete asphalt (0)	NL05
Concrete with metal broom treatment (+1)	NL07
Concrete with grooved apshalt (+2)	NL08
Cobblestones with smooth texture (+3)	NL12
Cobblestones with rough texture (+6)	NL10

NMPB 2008 (France)

Based on "Road noise prediction: 1- Calculating sound emissions from road traffic", Setra, June 2009, English translation Sept 2011

Notes:

1. The lookup tables below are set out in order to provide data migration from an NMPB 2008 model to a CNOSSOS-EU model;

2. The emission term is based upon the sound power emission of an equivalent point source on the emission line 0.05m above the road surface. At present the numerical equivalence of the NMPB 2008 road source to CNOSSOS has not been established. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. The single HGV class in NMPB 2008 has by default been split 50/50 amongst the 2 HGV classes in CNOSSOS-EU, where more detailed traffic flow data is available this ratio should be adapted to each project area;

4. The three road surface categories have been matched across to three of the Dutch road surface types of similar physical construction which provide a similar step change in levels. The dependences on speed, ageing and vehicle category in NMPB 2008 may not be accurately reflected in CNOSSOS. If this level of detail is required additional surface types could be added;

5. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

NMPB 2008 Vehicle class					CNOSSOS vehicle
No of Light Vehicles (includes motorised two wheel vehicles)					1
50% of No. of HGVs (includes buses)					2
50% of No. of HGVs (includes buses)					3
NMPB 2008 Road surface					CNOSSOS road surface
R1					NL14
R2					NL05
R3					NL08

RMG: SRM II 2012 (Netherlands)

Based on "Reken en meetvoorschrift geluid 2012, Standaardrekenmethode 2 (SRM2)"

Notes:

1. The lookup tables below are set out in order to provide data migration from an RMG SRM II model to a CNOSSOS-EU model;

2. The emission term is based upon the sound power emission of an equivalent point source on the emission line. At present the numerical equivalence of the RMG SRM II road source to CNOSSOS has not been established. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. The two HGV classes in RMG have been matched across to CNOSSOS-EU. The two tram categories in RMG are treated as road vehicles, if they are to be calculated in CNOSSOS-EU new vehicle categories would need to be added; therefore they have been assigned 5 and 6 in this proposal. Alternatively the trams in RMG SRM II should be converted to railway source vehicles in CNOSSOS-EU;

4. The 15 road surface types in RMG SRM II have been directly matched across to 15 road surfaces in the CNOSSOS database as these were taken from the Dutch method. These road surface corrections are lower than in the previous 2006 version of the standard in order to address aspects of road surface aging effects;

5. Other corrections for "the expectation that in the near future the noise emissions might be lower" have no direct equivalent in CNOSSOS-EU and have been ignored in these recommendations. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables;

6. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

RMG SRM II 2012 Vehicle class	CNOSSOS vehicle
No. of Light Vehicles (Cat=LV)	1
No. of medium-duty vehicles (Cat=MV)	2
No. of heavy vehilces (Cat=ZV)	3
No. of mopeds	4a
No. of motorcylces	4b
No. of trams on ballast	5
No. of trams (asphalt) concrete	6
RMG SRM II 2012 Road surface	CNOSSOS road surface
DC1/11, dac 0/16SMA 0/11	0
1-layer ZOAB	NL01
2-layer ZOAB	NL02
2-layer ZOAB (fine)	NL03
SMA-0/5	NL04
SMA-0/8	NL05
Brushed concrete	NL06
Optimized brushed down concrete	NL07
Fine broomed concrete	NL08
Surface treadment	NL09
Hard elements in herring-bone	NL10
Hard elements not in herring-bone	NL11
Quiet hard elements	NL12
Thin layer A	NL13
Thin layer B	NL14

RVS 4:02:11 2006 (Austria)

Based on "RVS 04.02.11 Lärmschutz (März 2006)" and AR-INTERIM-CM "WP 3.1.2: Road traffic noise - Noise emission: databases"

Notes:

1. The lookup tables below are set out in order to provide data migration from an RVS 4:02:11 model to a CNOSSOS-EU model;

2. The reference distance is 1m to the centre of the road lane. For information purposes a reference level in 25m distance may be calculated by subtracting 14dB. Until the CNOSSOS-EU propagation method is selected it is not possible to directly assess the numerical equivalence of the CNOSSOS road source with RVS 4:02:11. If numerical equivalence is important to the relevant authority this would need to be investigated, and additional input data added to CNOSSOS tables, at a later stage after selection of the basic CNOSSOS method;

3. The elementary noise source is located 0.5m above the ground. There has been no attempt to correct the emission for the difference in emission height compared to CNOSSOS-EU;

4. RVS 4:02:11 calculates overall L_{Aeq} noise levels, CNOSSOS-EU calculates octave band L_{Aeq} noise levels;

5. The two standard HGV classes in RVS 4:02:11 have been matched to the 2 HGV classes in CNOSSOS-EU. RVS also has two additional HGV classes for noise reduced light and heavy trucks which are generally 2 and 3 dB quieter on most road surfaces. These could be assigned to the same category as the unsilenced vehicles, or as currently identified they could be assigned to Category 5 and 6 and revised emissions terms used which provide the lower noise emission;

6. The four road surface types have been matched across to Dutch road surface types of similar physical construction which provide a similar step change in levels. The dependences on speed and vehicle category in RVS may not be accurately reflected in CNOSSOS. If this level of detail is required additional surface types could be added;

7. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculations.

RVS 4:02:11 2006 Vehicle class	CNOSSOS vehicle	
No. of cars (light vehicles) (m=1)	1	
No. of buses, commercial vehicles without trailer and motorcycles (medium vehicles) (m = 2)	2	
No. of low noise versions of medium vehicles (m=3)	5	
No. of trailer and semitrailer trucks (heavy vehicles) (m = 4)	3	
No. of low noise versions of heavy vehicles (m=5)	6	
RVS 4:02:11 2006 Road surface	CNOSSOS road surface	
Drainage asphalt (-2 to -6)	NL02	
Asphaltic concrete (0)	NL05	
Concrete or grooved asphalt (+1 to +2)	NL08	
Granite block pavement (+5 to +8)	NL10	

Annexes

Annex **1 –** Methodology for defining additional road surface coefficients

Annex **2 –** Methodology for defining additional rolling and propulsion noise coefficients

Annex 1 – Methodology for defining additional road surface coefficients

The road surface significantly affects the level of both the rolling noise and the propulsion noise; rolling noise through the excitation of the tyre structure by its surface roughness, rolling and propulsion noise through its absorption of the reflected components. Differences in pass-by noise levels of more than 15 dB can occur between rough transversely grooved concrete and 2-layer porous asphalt concrete. The figure below presents pass-by measurements of several thousand vehicles on two different surfaces. Clearly seen is the large effect of the surface, which dominates over the spread within the vehicle category.

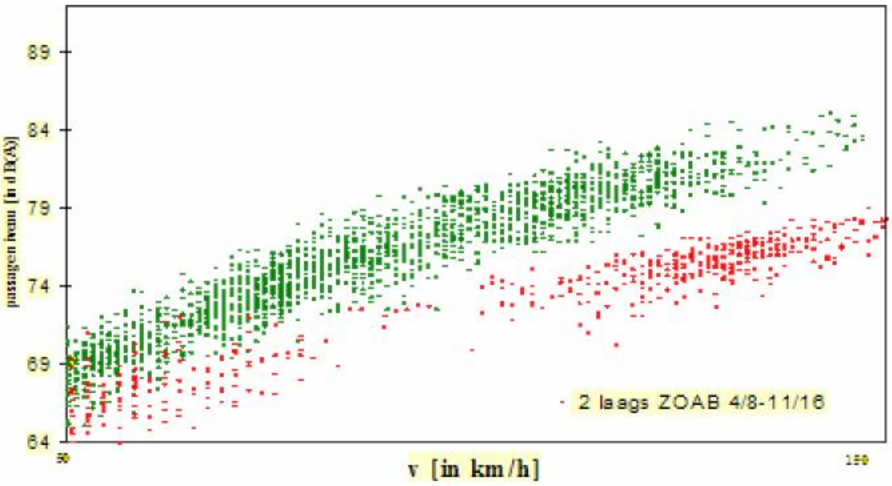


Figure A1-1: Effect of road surface type on pass-by noise.
Green dots: brushed concrete, red dots: 2 layer porous asphalt. (IMAGINE D11, 2007)

Within the 6th framework SILVIA project, an acoustic classification procedure for road surfaces was developed that formalizes the assessment of the road surface effect. This labelling procedure within in this classification system, is based on the effect it has on the noise level of passing vehicles and this effect is defined and formulated in such a way that it directly interfaces with the definition and formulation of the rolling noise and propulsion noise used in the IMAGINE model.

The coefficients in the formulation are determined according to a procedure developed by the SILVIA project and that is given in “Guidance Manual for the Implementation of Low-Noise Road Surfaces”, EU 5th Framework Project SILVIA Deliverable, FEHRL report 2006/02, 2006.

The reduction values are defined as a difference of the emission on a certain surface and the emission of that same category on the reference surface. Since these determination has to be done on trafficked roads, the mandatory measurement method is the SPB method, ISO 11819-1, “Acoustics - Measurement of the influence of road surfaces on traffic noise -- Part 1: Statistical Pass-By method”, 1997. Although the SPB method is slightly different from the preferred method applied in the IMAGINE study, the CPX method, it can be used since we only use it as determination of a difference and not an absolute value.

A few remarks:

1. IMAGINE did not assume any effect for motorcycles, firstly because rolling noise does not contribute to the overall level, second since reflection plays a lesser role in the propagation

2. one must carefully distinguish between the source effect and the propagation effect of porous surfaces. In the presented reduction values the local reflection is already included in the surface effect and shall not be included in propagation calculations.

IMAGINE D11 also suggests that it may be possible to determine the road surface correction directly while driving over the road network by combining the CPX method, Draft ISO 11819-2, “Acoustics — Method for measuring the influence of road surfaces on traffic noise — Part 2: Close-proximity (CPX) method”, with GPS data, the road surface corrections of an entire city road network could be measured in a single day.

It should be noted that ISO 11819-1 on the statistical pass-by method (SPB), and ISO 11819-2 on the close-proximity method (CPX), are currently subject to revision and may be added to in the foreseeable future by ISO 11819-3 on reference tyres, and ISO 11819-4 on the SPB method using backing board.

Further information on measurement procedures is also provided in the report from the Silence project, deliverable F.D13 “NOISE CLASSIFICATION METHODS FOR URBAN ROAD SURFACES Classification Methodology”, whilst TRL report PPR443 “A review of current research on road surface noise reduction techniques”, 2010, also provides information on noise performance of aging road surfaces, and cost benefit assessment in the context of noise action plans.

Annex 2 – Methodology for defining additional rolling and propulsion noise coefficients

For each road vehicle, the emission model consists of a set of mathematical equations representing the two main noise sources:

1. Rolling noise due to the tyre/road interaction;

2. Propulsion noise produced by the driveline (engine, exhaust, etc.) of the vehicle.

Aerodynamic noise is incorporated in the rolling noise sources, since the chosen method for determining the sound power level involves coast-by events, thus making it impossible to distinguish between the two.

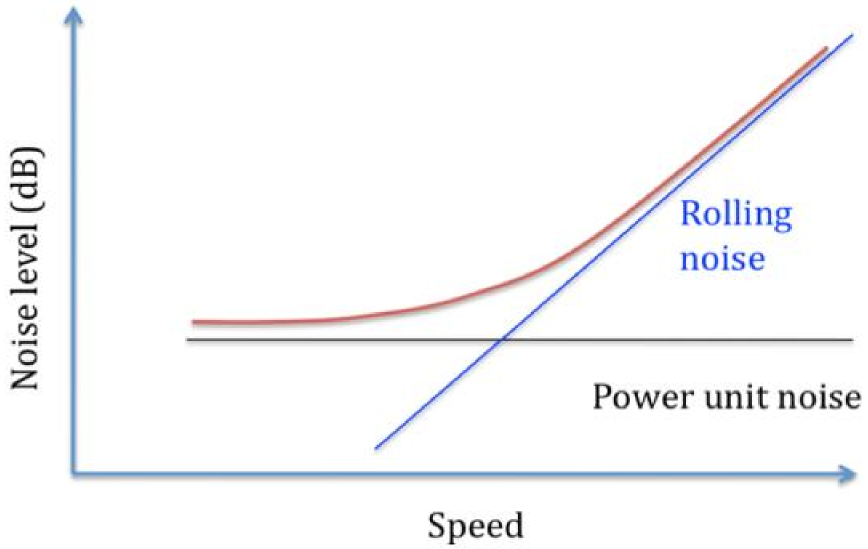


Figure A2.1: Principle of changes in overall noise level L_{Amax} depending on the speed, with an engine contribution independent from the speed. (Setra 2009)

The general form of the mathematical expression for the sound power level emitted by one of the sources (rolling or propulsion) as a function of the vehicle speed v m (20 km/h ≤ v_m ≤ 130 km/h) is:

$$L_{W,i,m}(v_m) = A_{i,m} + B_{i,m} \cdot f(v_m)$$

with $f(v_m)$ being a logarithmic function of v m in the case of rolling and aerodynamic noise, and a linear function of v m in the case of propulsion noise.

This general approach requires the rolling noise coefficient and the propulsion noise coefficient to be determined for each vehicle category. The TNO report HAG-RPT-000048[1] from 2000 published

[1] J.D. van der Toorn, W.J.A. van Vliet. TNO-report HAG-RPT-000048, 18 May 2000. *Emissiekentallen motorvoertuigen 2000, gebaseerd op metingen uit 1996 en 1999* (Emission characteristics of motor vehicles 2000, based on measurements performed in 1996 and 1999; in Dutch

the results of many vehicle measurements which were analysed to derive *A* and *B* coefficients in the updated Dutch standard Calculation Scheme II (SRM II). At about the same time Version 1.0 of the new Nord2000 method was developed along similar lines[2] based upon analysis of from several thousand measurements of the SEL-level during pass-by.

This approach was referenced and further developed upon under Harmonoise[3]. It was reported that:

> *"Many measurements, see [24], have been carried out on vehicles in real traffic. CPX measurements have been used to separate different noise sources from each other. Some examples of measurement results are shown."*

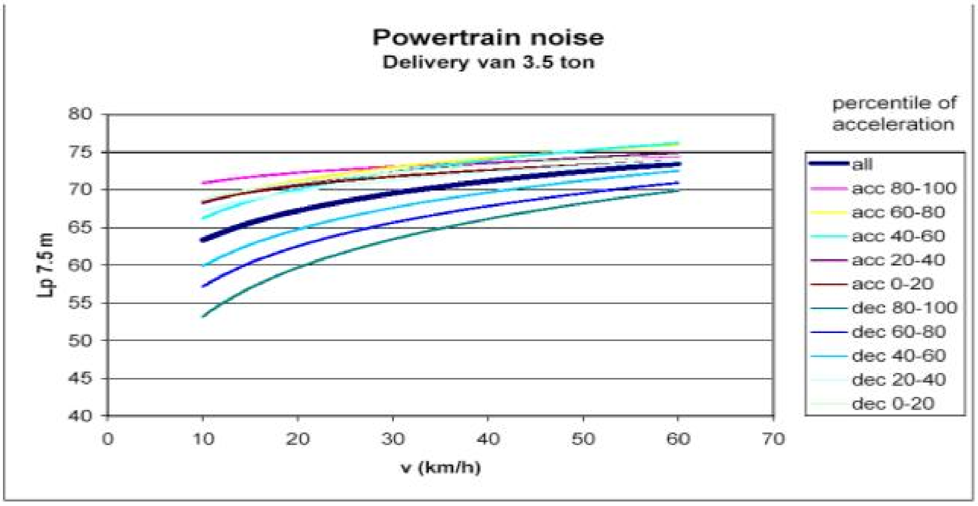
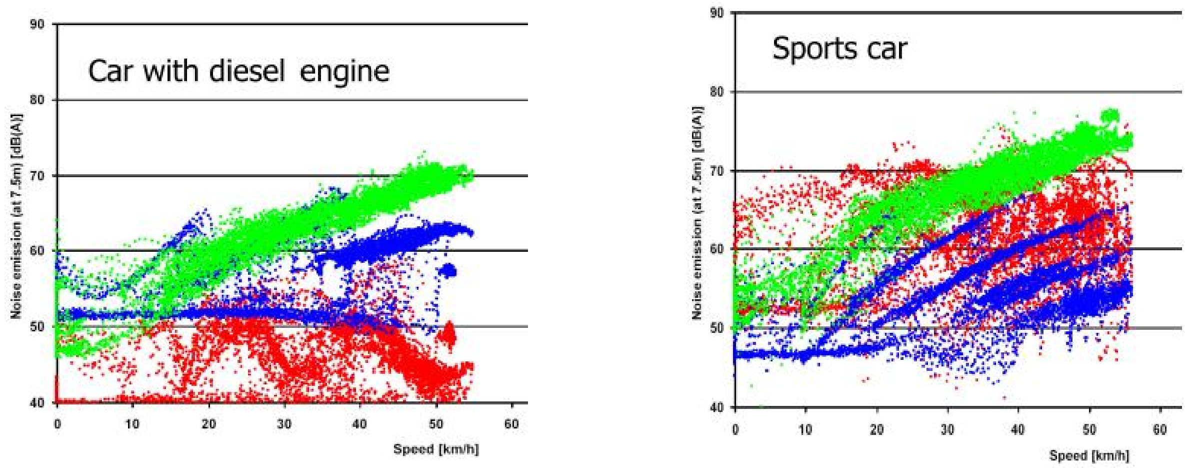


Figure A2.2: A-weighted sound pressure levels at 1.2m/7.5m as a function of speed and acceleration (Setra 2009)



green= rolling noise, blue = engine noise, red = exhaust noise

Figure A2.3: A-weighted sound pressure levels at 1.2m/7.5m as a function of speed and acceleration (Harmonoise 2003)

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[2] H.G. Jonasson and S.A. Storeheier, Nord2000. *New Nordic Prediction Method for Road Traffic Noise*, Version 1.0, SP Report 2001:10, Boras 2001.

[3] Harmonoise Work Package 1.1 report "Source modelling of road vehicles" HAR11TR-020614-SP-05, June 2003

During the Harmonoise project, the measurements were analysed in 1/3 octaves bands and transformed into equations yielding the sound power levels for the different conditions. Different methods to determine power train noise was also analysed[4]. One method is to carry out both cruise-by and coast-by measurements and then subtracting one from the other. The results indicated that engine noise dominates around 80 Hz where the engine has its firing frequency and that rolling noise for passenger cars dominates strongly around 1250 Hz where the horn effect has its maximum. The Harmonoise project proposed intermediate values for the *A* and *B* coefficients for rolling and propulsion noise, on the basis that a definitive set of coefficients would be developed within the framework of the IMAGINE project.

In IMAGINE the rolling and propulsion coefficients for Category 2, 3 and 4 vehicles were developed. Measurements of power two wheel motorbikes and mopeds were analysed by multi-regression analysis to develop coefficients for Category 4a and 4b[5].

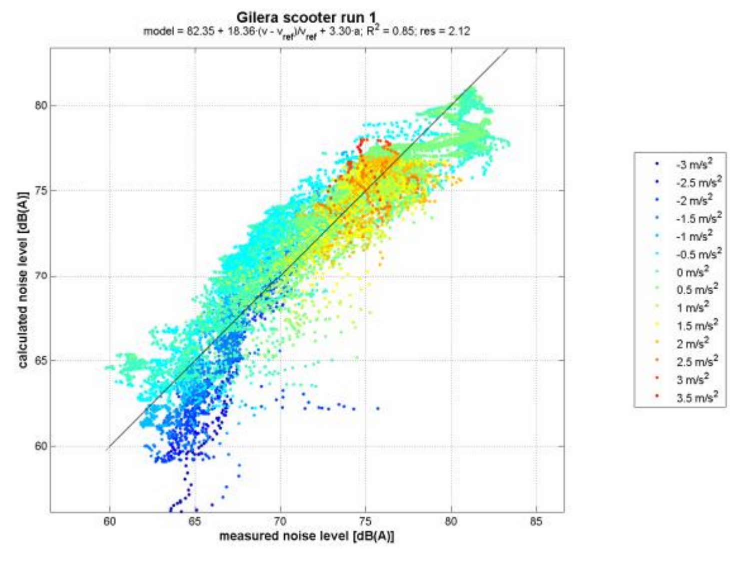

Figure A2.4: Linear model of the sound power level as Lp = a + b.v + C.acc; correlation $R^2 = 0.85$, residue = 2.1 dB(A) (IMAGINE 2006)

For heavy vehicles measurements were undertaken at the Volvo test laboratories and in the field to collect data to use to validate the Harmonoise model[6]. Different methods to separate propulsion and tyre/road noise are discussed in Section 2, and some measurements combined with a transfer matrix method indicate that the point source model of Harmonoise functions reasonably well. The Harmonoise coefficients were also re-analysed using several thousand sets of measurement data from a number of Nordic countries, details were described in 2006[7]. The outcome was a revised set

[4] Harmonoise Report HAR11TR-021231-TRL04 Comparison of methods for measuring power train noise
[5] IMAGINE Deliverable 3 *Assessment Programme for Parameters of the "general" European vehicle fleet*, IMA52TR-060111-MP10, January 2006
[6] Hans Jonasson, *Noise Emission of Heavy Vehicles*, SP Report ETa 6140-5, Energy Technology, Borås 2005
[7] Hans G. Jonasson, *Acoustic Source Modelling of Nordic Road Vehicles*, SP Rapport 2006:12, Energy Technology, Borås 2006

of coefficients which were passed into the IMAGINE project[8] which combined a series of data acquisition and analysis projects.

Section 4.5.2 of the IMAGINE Deliverable 11 report states:

> *"It can be stated that the accuracy of our model increases with the importance of the parameters. We have spent most of our data acquisition effort and analysis time on gathering reliable spectra for the A coefficients, which represent the noise spectrum of each vehicle category at the reference speed of 70 km/h, with no acceleration and further reference conditions. The total of rolling noise and propulsion noise at this speed has been validated against many measurements. We believe that these values are an accurate representation of the European average vehicle, for each main category.*
>
> *Second are the B coefficients, representing the influence of vehicle speed, also per 1/3-octave band. The speed dependence of the total noise has been validated against roadside measurements and corresponds to values found in other national and interim calculation methods.*
>
> *The distinction between rolling and propulsion noise is based on dedicated measurement campaigns on test tracks, or on specific vehicles, but cannot be measured on large quantities of vehicles. The fact that propulsion noise dominates for lower vehicle speeds and higher accelerations, and dominates more for heavy vehicles than for passenger cars, is represented by our model, and the vehicle speeds at which the "break-even" point between the two occurs is in agreement with our experiences."*

Whilst the final report includes graphs of the coefficients in Section 4.2, it does not contain the exact values in tabular format, instead referring to an Excel database "*which may be obtained through the WP5 partners*".

Should it be considered necessary to develop additional A and B coefficients for rolling and propulsion noise emission, it would be necessary to undertake a measurement campaign in line with those referenced above. Unfortunately at present there is no standardised approach to follow in order to derive the relevant coefficients; however an outline of the general procedure is discussed below.

The aim of a measurement campaign is to collect the input values to fill into the CNOSSOS-EU model. Several vehicle categories could be addressed, under the three running conditions:

- Constant speed,
- Accelerating / decelerating
- Uphill / downhill

The vehicle speed, gradient and road surface type should all be captured if they vary from the reference conditions in CNOSSOS-EU

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[8] IMAGINE Deliverable 11, *The Noise Emission Model For European Road Traffic*, IMA55TR-060821-MP10, January 2007.

SEL pass-by levels at 7.5m from the centre of the running path, and at 1.2m and 3.0m heights should be taken in third or whole octave bands. Measurements should be undertaken in line with the requirements of ISO 11819-1[9].

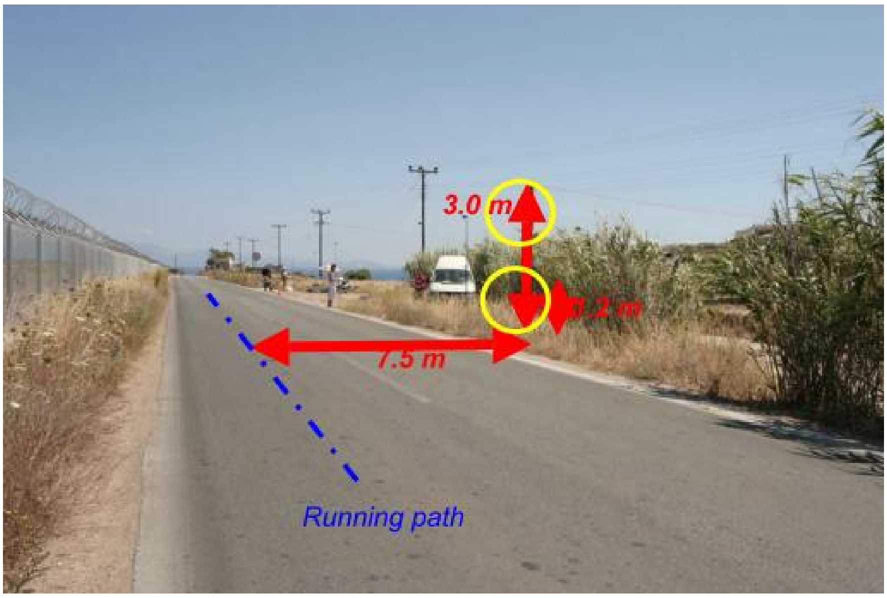

Figure A2.5: Flat straight road in open location for single vehicle pass-by measurements under constant speed (IMAGINE 2007)

Where possible the road surface texture and impedance should be measured, or a reference surface could be used. Where this is not possible it is recommended to use a dense asphalt concrete or stone mastic asphalt and report the main characteristics should it be necessary to correct the measurements for road surface type.

Measurements should be undertaken at a range of speeds for each vehicle in the tests program.

If a small number of vehicles are to be measured, it may be possible to measure the propulsion noise directly, as discussed in IMAGINE D11 for HGVs and powered two wheel vehicles.

For acceleration coefficients measurements should be undertaken in close proximity to crossing junctions or toll stations whilst also measuring the vehicle acceleration, as discussed in IMAGINE D11.

The sound pressure spectra captured during the measurements are then used in a regression analysis to obtain the coefficients. The regression analysis should be undertaken at the reference speed in order to develop new *A* values, and then at different speeds to get the new *B* values. The regression analysis can be fraught with uncertainty if a large sample set is not available, and it may be worth assuming that above 1000 Hz the noise level is likely to be dominated by tyre/road noise at higher speeds, and that engine noise may be ignored for light vehicles in these situations. If measurements are undertaken over a range of speeds, it may also be worth identifying situations

[9] ISO 11819-1:1997, *Acoustics -- Measurement of the influence of road surfaces on traffic noise -- Part 1: Statistical Pass-By method*

where either propulsion or rolling noise will dominate and analyse then in isolation from the intermediate cases.

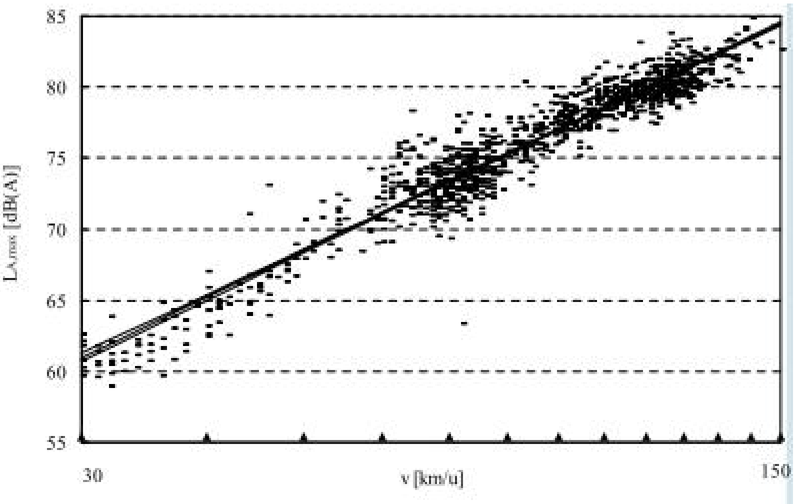

Figure A2.6: Regression analysis used to obtain *B* coefficient (IMAGINE 2007)

As a first estimate it may be worthwhile to assume that the split between rolling and propulsion noise is in the same ratio as in the default CNOSSOS-EU database, provided that the appropriate asphalt type is provisionally used in the formula to help avoid the new values being a combination of vehicle and asphalt type changes.

Finally the results of the analysis should be converted from sound pressure to sound power levels, taking into consideration the source directivity and microphone positions and appropriate.

As good practice the derived coefficients should then be used within the CNOSSOS-EU road source calculation and cross checked back to the measurement results in order to estimate uncertainty in the derived values.

Additionally, there is also discussion and guidance on the use of vehicle pass-by measurements to derive A and B coefficients in the context of NMPB 2008[10]. Unfortunately due to differences in approach between NMPB 2008 and CNOSSOS-EU, the report cannot be used as general guidance as the numerical analysis is on the basis of a single overall value for NMPB 2008, rather than per third octave or octave band as required for CNOSSOS-EU.

[10] *Road noise prediction: 1 - Calculating sound emissions from road traffic*, Setra, June 2009