DRAFT REPORT

WORKSHOP

on

"Selection of common noise assessment methods in EU"

8 – 9 September 2009, BRUXELLES

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1. SCOPE AND METHODOLOGICAL CONTEXT

Within the framework of the European Environmental Noise Directive (END) 2002/49/EC, the article 6 of the END states that: "*common assessment methods for the determination of L_{den} and L_{night} shall be established by the Commission in accordance with the procedure laid down in Article 13(2) [regulatory committee] through a revision of Annex II*".

During the Noise Regulatory Committee meeting took place on the 7^{th} of May 2008 in Bruxelles, DG ENV informed the Member States that the Commission, for ensuring consistency of noise exposure data across the EU, intends to come up with common noise assessment methods for environmental noise mapping in the context of the review of the Environmental Noise Directive. The EU MS anticipated their willingness to support this initiative of the Commission.

Several of the existing methods were considered as possible candidates in the context of the aforementioned harmonisation approach. Therefore, the aim of the work undertaken by the JRC was to scrutinise possible candidate methods for further consideration in preparing the common noise assessment methods.

A sound evaluation of the existing methods on the basis of appropriately chosen criteria that shall provide a good understanding of the capabilities, strengths and weaknesses of the candidate methods was performed in the period July-August 2009.

A screening and rating of the candidate methods (more methods for each of the four major noise sources) identified by DG JRC and agreed upon by DG ENV was performed on the basis of specific criteria elaborated with the assistance of a team of EU noise experts including the European Environment Agency's Experts Panel on Noise (EPoN) group.

Following these criteria, the methods which best cover the needs and requirements of the END with regard to strategic noise mapping were identified, scrutinised and finally have been further discussed during the Workshop on "*Selection of common noise assessment methods in EU*" took place on 8-9 September 2009 in Brussels. The main aim of this Workshop was to reach consensus about the components the common noise assessment method(s) should be composed of.

The Workshop was performed in the context of the roadmap to prepare common noise assessment methods in EU to be used by Member States for strategic noise mapping according to the European Environmental Noise Directive 2002/49/EC. This project is co-ordinated by the Directorate General Joint Research Centre on behalf of DG ENV in collaboration with the European Environment Agency's Experts Panel on Noise (EPoN) and a network of noise experts.

This Workshop corresponds to task V of the overall work plan which is presented in table 1.

The Workshop's agenda can be found in Annex B and a list of the Workshop's participants in Annex C.

Table 1. Overall work plan related to the roadmap for the preparation of common noise assessment methods in EU

Task N.	Task description	Dates
I	*A short report will be prepared and delivered by JRC to the network of noise experts including* ***a set of criteria*** *to be used for the selection of candidate methods. The set of criteria will be fine tuned and finalised on the basis of comments received from the network of experts.*	12/06/2009 to 15/06/2009
II	*A report will be prepared and delivered by JRC to the network of noise experts containing a* ***list of methods that meet the criteria*** *previously agreed upon and a final report including* ***a pre-selection of*** *those* ***methods*** *that fulfil the criteria will be prepared taking into consideration the comments of the network of experts received.*	19/06/2009 to 03/07/2009
III	***Technical documentation on the formulas and the associated databases used*** *for each part of the pre-selected methods will be collected and elaborated by JRC.*	06/07/2009 to 21/08/2009
IV	***Different options concerning the various parts of the noise assessment methods*** *will be elaborated by the JRC assisted by a number of experts and delivered to the network of noise experts for comments.*	28/08/2009 to 04/09/2009
V	**TECHNICAL WORKSHOP on "*Selection of common noise***	

	assessment methods in EU": • *Thorough* **discussion** *on the* **different options suggested** *for the various parts of the noise assessment methods and* **selection** *of those to be used in the common noise assessment methods.* • ***Conceptualisation*** *of a* ***'fit for purpose' framework*** *for the noise common assessment methods (algorithms, settings and default set of input values). and preparation of a first report outlining them.*	08-09 /09/2009 Bruxelles
VI	*A* **report** *summarising* **the rationale behind the selection of the various parts** *of the noise assessment methods and* **describing the** ***'fit for purpose' framework*** *will be prepared by JRC and delivered to the Network of Noise Experts for comments.*	1/10/2009 to 20/10/2009
VII	***Drafting of the common noise assessment methods:*** *A draft report containing a transparent and usable version of the noise common assessment methods (algorithms, settings and default set of input values) will be prepared by JRC assisted by a small number of noise experts and delivered to the Network of noise experts for comments.*	15/12/2009
VIII	***Good practice guidelines*** *on the appropriate use of the common noise assessment methods will be prepared in connection with the data requirements and in line with the 'fir for purpose' framework.*	1/12/2009 to 15/04/2010
IX	***A final draft report on the common noise assessment methods*** *will be prepared and delivered to DG ENV for comments and further submission to the Noise Regulatory Committee.*	28/02/2010
X	***A final JRC Reference Report on the common noise assessment methods inEU*** *will be issued and distributed to the EU MS and other relevant stakeholders.*	30/04/2010

The discussion of the Workshop was steered by the contents of table 2 (see Annex A) which contains the components of the methods qualified during Task IV of the roadmap. The major outcome of the Workhop's discussions along with the consensus received on the various components of table 2 are presented in chapter 2 of the present report.

It should be underlined the fact that, as the Workshop's discussions pointed out the necessity to perform a few benchmark studies and a ad hoc Workshop on aircraft noise before a consensus throughout the entire list of the entries of table 2 in Annex A can be achieved, it is expected that tasks VII, VIII, IX and X of the roadmap will be slightly shifted in time.

2. SUMMARY OF WORKSHOP's DISCUSSIONS AND OUTCOME

The Workshop was opened by DG JRC, DG ENV and EEA. DG JRC introduced the scope and objectives of the Workshop and summarised the work performed together with a team of noise experts and the EEA's Expert Panel on Noise in the period from March 2009 to August 2009.

In the aforementioned period, one report was prepared and distributed to the network of the noise experts on 15 June 2009 on the requirements and the criteria relative to the selection of the common European noise mapping methods. This report was followed by a second one concerning the evaluation of and pre-selection among the existing noise assessment methods on the basis of an extended literature review and the requirements and criteria established from report one.

On 5 August 2009, the aforementioned second report was delivered to the EU network of noise experts associated to the roadmap (most of them participated in the Workshop).

Concerning the requirements and criteria for the common noise assessment method provided by the first report, on the basis of the experts' feedback, some minor adjustments were suggested for the table of criteria and requirements; however, none of these changes affected the final assessment of the methods. Also the feedback received from the network of experts on the second report will be included in the revised version of the report to be distributed in October 2009.

As far as the problem with royalties and Intellectual Property Rights identified in the report (mainly related to the *Harmonoise/Imagine* project), this issue was positively resolved as during August 2009, almost all the developers of *Harmonoise/Imagine* accepted to remove the property rights on both parts of the method, the propagation part and the modelling of the sources.

Based on the agreed criteria, the evaluation exercise qualified the following methods as the most appropriate to be further processed for preparing the common noise assessment methods:

- ***HARMONOISE/IMAGINE and NORD2000*** **for road, railway and industrial noise**
- **Further investigation on *ECAC-Doc29* and *AzB* has to be performed for aircraft noise, since both methods fulfil most but not all the essential requirements outlined during the previous technical discussions held among the noise experts.**
- **Other methods were also qualified because they contain components resulted from research investigations recently concluded that could eventually be used in**

the common method: *ASJ RTN 2009* and *NMPB 2008* for roads, *RVS* and *Schall03* for railway and *ISO 9613* for industrial noise.

During this workshop the components of the aforementioned qualified methods were thoroughly discussed and consensus was received by vote about those to be finally used for the propagations and source parts in the common noise assessment methods. The workshop's discussions revealed that for some of the components some further investigation is needed before to make a final decision.

A summary of the discussions, the resolutions made for each of the components as well as the list of follow-up actions is given below:

SOUND PROPAGATION

A1: Geometrical divergence

Concerning the geometrical divergence, the entries under part A1 of the table in Annex A revealed that almost all of the preselected methods are practically using the same approach. Therefore,

- ***It was unanimously decided that the formulas on geometrical divergence used by the EU preselected methods should be adopted.***

A2: Atmospheric absorption

It was discussed whether this coefficient should be introduced in 1/3 octave or in octave bands as the effect on the results can be as high as 3 dB(A). For a detailed modelling, the 1/3 octave band approach is necessary, whereas the octave band is sufficient for mapping purposes. As the common noise assessment method(s) has to address both levels of details, it has to include the most advanced knowledge up to now. In the implementation phase, depending on the availability of input data, a full 1/3 octave band calculation can be made or, alternatively, by simplifying and allowing some inaccuracies, an octave band can also be used. 1/3 octave band calculation is compatible with aircraft noise methods (e.g. Annex D of ECAC doc. 29)

- ***It was decided by vote that the requirements for the common method is 1/3 octave band calculation for atmospheric absorption. The NORD2000 formula should be used.***

A3: Terrain profile

All the methods under consideration use digital terrain models. However, NORD2000 and HARMONOISE/IMAGINE offer the best solutions that are not comparable to the rest of the existing models. Both use the line segmentation technique and are identical. For aircraft noise, terrain models are used to calculate the distances between the source and the receivers but not for the ground effect on sound propagation, for which flat ground conditions are assumed due to high angles of incidence. However this has to be checked for *AzB*.

> - ***It was decided by vote that the common method should adopt the terrain profile description used either in NORD2000 or HARMONOISE/IMAGINE including buildings for road railway and industrial noise.***
> - ***For aircraft noise both Doc29 and AzB will be further considered.***

A4: Ground effect

NORD2000 and *Harmonoise/Imagine* have shown good agreement in the benchmark performed in the context of the *Harmonoise project* for several ground conditions. In both methods, the basic formulas are the same, but the combination of effects (e.g. ground effect and meteorological effect) is different. In addition to these two methods consideration will be also given to the formulas of NMPB 2008 as these are different and more updated.

Several experts expressed concerns about the low quality of input data available and the uncertainty on the results when using this data in a sophisticated model. It was recalled that the purpose is to provide the most detailed or advanced method as a common reference and that implementation will depend on the quality of input data. It was acknowledged that sophisticated input data are expensive and difficult to obtain but this may be improved in the future and then lead to an optimized prediction. If an advanced method is not adopted at the moment, for the time it will be used, it might become obsolete and not appropriate to all purposes foreseen anymore.

Concerning aircraft noise, *AzB* takes into account the ground effect, whereas *Doc29* does not. On the other hand, *AzB* does not consider installation effects. It is not clear yet if the *AzB* formulation of ground effect is compatible with *Doc29* method and if it could be introduced in it. Furthermore, it was suggested that integration between *AzB* or *Doc29* and *Harmonoise*/*Imagine* sound propagation model to be performed for low angles of incidence. This integration should at least apply for aircrafts on the ground (e.g. when taxiing) to appropriately consider all airport sources.

> - ***It was decided by vote that the formulation of ground effect in HARMONOISE/IMAGINE NORD2000 and NMPB should be considered in the reference method for road railway and industrial noise.***
> - ***For aircraft noise a specific meeting will be organized before the end of 2009 in order to obtain a clearer view about the issue on ground effects.***

A5: Reflections

Simplification of the official formula given for *NORD2000* (see table in Annex B) may have been introduced in the *NORD2000* software. This should be checked.

> - ***It was decided by vote to use two or three reflections and adopt provisionally the NORD2000 formula as a reference and to further investigate for its implementation with the software developers in a forthcoming ad hoc meeting.***

A6: Diffractions / screening obstacles

More exact equations are used in NORD2000, however Harmonoise/Imagine adopt a simpler approach which is easier to implement in software also this also speeds up the calculation time.

NMPB2008 uses similar formulations to Harmonoise/Imagine but with combination with ground effect.

Harmonoise/*Imagine* and *NMPB2008* seem both to work for barriers on embankments, and for low barriers. *NMPB2008* has been validated more compared to Harmonoise/Imagine especially concerning real environment configurations.

The French government has recently launched a study for comparing *NMPB2008* and *Harmonoise*/*Imagine*.

> - ***It was decided by vote to keep open the choice between HARMONOISE/IMAGINE formulation and NMPB2008 to allow further verification and test case comparisons before to decide which of them will be introduced in the common method.***

A7: Modelling of meteorological influence (effect of temperature, pressure, wind speed and direction)

In *Harmonoise/Imagine*, 25 classes of meteorological conditions are defined to cover the range of specific situations in Europe. Favourable conditions are useful for validation cases. In Denmark, experimentations have demonstrated that only 4 classes would cover most of the situations. In city streets, only 1 class is enough.

In *NMPB2008*, only 2 classes of conditions are defined. A factor of probability of occurrence is needed for each condition. They are defined according to micro-meteorological data provided by National Meteorological Institutes. As soon as these data are available, the computation of the maps of occurrence and of the wind speed and temperature gradients is quick. It was recently found out that there are so many meteorological data available throughout Europe that this kind of map can be easily made in any place.

The number of classes to be considered is a matter of accuracy, but this has to remain a technical decision.

For aircraft noise, only 1 meteorological class is used per airport. The temperature can be adapted to seasonal effects, night/day conditions and airport specifics. Temperature affects aircraft performances. Wind speed effect on sound propagation is of second order as this monitors the taking off direction and the aircraft performance.

- ***For meteorological effect it was decided by vote to consider the formulation and the different classes as defined in HARMONOISE/IMAGINE. However, in the guidelines for appropriate use of the common methods the use of a reduced number of classes should be specified.***

SOURCE SPECIFICS: ROAD

B1: Classification of vehicles

Harmonoise/Imagine and NORD2000 use the same classification of vehicles with the only difference being that the vehicle classes of NORD2000 have been derived from local measurements in Sweden. It was discussed and agreed that it is important to allow flexibility in dealing with the classification of vehicles as the vehicles fleets are greatly varying over Europe. In *Harmonoise/Imagine*, 15 classes of vehicles have been defined, and among them, 4 have been selected as "main classes".

> - ***It was decided by vote that the reference method should adopt the 4 classes as defined in HARMONOISE/IMAGINE and in the guidelines for the use of the common methods to clarify the weighting and define more precisely the classes.***

B2: Speed dependence

Separation of propulsion noise and tyre noise is essential for urban conditions. *NORD2000*, *Harmonoise/Imagine* and *NMPB2008* separate propulsion noise and tyre noise. There is a need to create data on measurements available to EU MS in order to reflect differences among the EU MS (i.e., the EU database on data recommended in the Workshop on Data took place in March 2009 in Ispra).

> - ***It was decided by vote to consider HARMONOISE/IMAGINE for the description of formulas. The way to handle those situations not separating between propulsion and rolling noise and to adapt the parameters to local conditions by updating them through measurements to be fed into a common EU database should be explained in the guidelines for the use of the common methods.***

B3: Acceleration/deceleration (traffic flow)

In *Harmonoise/Imagine*, it is a constant correction factor of the proportion of engine noise. It is unlikely that anybody used it during the 1st round of noise mapping as it is too academic. However, this is important to keep this function for refined modelling purposes as those required by action plans.

> - ***It was decided by vote to adopt the corrections for acceleration/deceleration as defined in HARMONOISE/IMAGINE. The guidelines for the use of the common methods will specify where and when to use this feature.***

B4: Gradients

In *Harmonoise/Imagine* the handling of gradients is equivalent to that handling acceleration/deceleration. There is an additional correction factor to take into account the extra noise from trucks using the engine brake in downward slopes.

In *NMPB2008*, the parameter is the gradient. There is a correction for acceleration and deceleration for different types of traffic flows, deriving from a large set of experimental data.

There is an obvious need expressed by most participants to exchange the data and compare *Harmonoise/Imagine* and *NMPB2008*. JRC is in favour of such a benchmark as long as it fits to the tight time-frame associated to the preparation of the common noise assessment methods: it must be kept in mind that the common method(s) has to be ready much before the 2nd round of mapping will start.

- ***It was decided by vote to provisionally include the HARMONOISE/IMAGINE approach and to launch as soon as possible a benchmark with NMPB2008 for comparing the data and the accuracy.***

B5: Road surface type correction

In *Harmonoise/Imagine*, a simple default correction is defined according to the maximum chipping size, with reference to a dense asphalt 16 mm: 0.25 dB(A) per mm. In addition, corrections are proposed regarding ageing effect and a reference to *SILVIA* guidelines is made for the determination of the correction factor. For drainage asphalt, a change of surface impedance is introduced.

In *NMPB2008*, there is no impedance effect of porous asphalt but a change in the emitted sound power spectrum.

The reference to which the correction factor is defined is an issue because it is not the same in all the countries over Europe.

- ***It was decided by vote that regarding the differences in pavement definitions and in national database to adopt the HARMONOISE/IMAGINE principles and to describe in details in the guidelines for the use of the common methods how to introduce national data.***

B6: Tyre type correction

Harmonoise/Imagine is the only method that introduces a tyre type correction for studded tyres.

- ***It was decided by vote that the only tyre type correction to be introduced should be the one proposed by HARMONOISE/IMAGINE for studded tyres.***

B7: Engine noise/exhaust noise

Both in *Harmonoise/Imagine* and *NMPB2008*, exhaust noise is not specifically considered. However, it is recognised that in some specific cases of an extremely high exhaust pipe (on some trucks for example) it may be of interest to consider a specific coefficient. This could actually refer to "specific" noise source rather than be restricted to "exhaust" noise source.

- ***It was decided by vote that the expression in HARMONOISE/IMAGINE with a single correction coefficient for engine/exhaust noise should be adopted although it is known that in some specific cases this correction coefficient might be considered as describing also other "specific noise sources".***

B8: Aerodynamic noise

- ***It was recognised by all participants that this feature is not relevant and therefore it will not be included in the common noise assessment method(s).***

B9, B10, B11: Bridges, tunnels and viaducts

Only the Japanese model *ASJ RTN2009* has is specifically handling bridges, tunnels and viaducts. The EU models usually take into account the sound propagation effects due to the specific geometry but do not consider the structure borne sound radiation.

- ***It was decided by vote that user defined corrective values of sound power can be introduced in HARMONOISE/IMAGINE approach to account for bridges tunnels and viaducts. In absence of a European solution provisionally the correction coefficients proposed in the Japanese method should be looked at along with the implications their inclusion might have to the HARMONOISE/IMAGINE algorithm.***

B12: Crossings

In all of the pre-selected methods, crossings are handled by acceleration/deceleration conditions.

- ***It was decided by vote to leave the "crossings" as an item and to explain in the guidelines for the use of the common method(s) that this feature can be taken into account by acceleration/deceleration and that traffic flow*** *modelling is required to properly address the acceleration and deceleration.*

B13: Segmentation of the source

It is usually described in a specific chapter in the methods. It can be considered as being an issue of implementation mostly for the software developers, however, minimum requirements should be specified for example related to the distance between point sources. It should also be guaranteed that segmentation should be consistent regardless of the segmentation method chosen.

- ***It was decided by vote to leave the issue of the segmentation of the source open for further discussion during the ad hoc meeting with software developers and also to provide guidance about the way to perform segmentation in relation to the accuracy to be achieved. A potential benchmark of various software could help in clarifying the requirements related to the segmentation of the source.***

B14: Source(s) position

Historically, many source positions were defined all over Europe. There has been since long time a strong debate on the subject.

In *Harmonoise/Imagine*, the source height is 0.01 m for tyre/road noise source and 0.75 m for the engine noise source

In *NMPB2008*, the equivalent source is 0.05 m above the ground, as it gave better fitting with advanced measurements (array techniques) and measurements/model simulations at different distances from the road.

Anyway, both approaches, *NMPB2008* and *Harmonoise*/*Imagine* are similar and there is no contradiction especially at higher speeds where the tyre source dominates. The source height is of minor importance for sound propagation calculations. However it is important for the determination of sound power from sound pressure measurements close to the source, i.e. for database constitution.

- ***It was decided by vote to adopt the 3 source positions as defined in HARMONOISE/IMAGINE.***
- ***For the emission data collection the relevant height (0.01 m or 0.05 m) will be decided after having performed a benchmarking between Harmonoise/Imagine and NMPB2008 which was considered necessary for identifying the source location. A specific meeting will be organised where both parties will have to bring in and discuss the scientific evidence of the***

choices they made.

SOURCE SPECIFICS: RAILWAY

M. Paviotti showed two slides that were presented at the UIC (Union Internationale des Chemins de fer) meeting taking place the same day in Paris. This is rather unfavourable to *NORD2000* and *Harmonoise/Imagine*, essentially due to the complexity of the method and high calculation times in practice. The position taken by UIC is in favour of tested method, but at the same time recommends the source description as used in *Imagine*. It was recognised among the Workshop participants that the compromise between accuracy and calculation time is a real challenge, but *Harmonoise/Imagine* already reduced time calculation by a factor of 10 and further reductions can be obtained by simplifying the input data in the simulations.

C1, C2: Wheel and rail roughness

For wheel roughness, a simple category coefficient can be defined, but more effort is needed on the rail roughness.

In *Harmonoise/Imagine*, a transfer function between rail roughness and noise is used for noise prediction.

In *Schall03*, two rail roughnesses are defined: one for composite block brakes and one for disk brakes.

> - ***It was decided by vote to adopt the HARMONOISE/IMAGINE approach i.e. keep separate formulas for wheel and rail roughness expressed in 1/3 octave bands. The guidelines will explain how the formulas can be used in connection with national databases.***

C3: Classification of vehicles/ locomotives

In *Schall03*, generic types of vehicles are used.

In *Harmonoise/Imagine*, there are about 230 examples of spectra and it was observed that a lot of vehicles have similar transfer functions roughness/noise.

> - ***It was decided by vote to introduce the class description of Schall03 in the HARMONOISE/IMAGINE approach. The guidelines for the use of the common method(s) will specify how to use other national classifications and attribute correct spectra.***

C4, C5, C6, C7, C8: Rolling engine and aerodynamic noise / speed dependence; squeal and braking noise

Schall03 defines independent speed corrections for rolling, engine, aerodynamic and equipment noise.

In *Harmonoise/Imagine*, there are no explicit speed corrections but speed dependence is introduced by the spectrum change in the roughness/noise relation. Both approaches are coherent as they define noise power spectra.

- ***It was decided to adopt the IMAGINE approach for rolling noise. The guidelines for the use of the common method(s) should explain how to cope with national database. Initially, the German database from Schall03 should be used.***
- ***For engine noise and aerodynamic noise the corrections from Schall03 should be introduced.***
- ***For squeal noise, the corrections on the source from Schall03 should be introduced.***
- ***For braking noise, the spectra from IMAGINE should be adopted.***

C9, C10, C11, C12, C13: Track/support structure classification, bridges, tunnels and viaducts and crossings

In *Harmonoise/Imagine*, 7 or 8 types of tracks are defined according to the transfer function roughness/noise. In *Schall03*, 4 different types of bridges are defined, each of them by a single value correction. For the 3 different types of tracks, octave band corrections are defined.

In *Schall03*, specific corrections are introduced for crossings. In *Imagine*, crossings are introduced by introduction of extreme additional roughness.

- ***A 2-step approach was decided by vote to be adopted:***
    - ***The IMAGINE approach should be considered for crossing and track support. It will be checked whether the Schall03 database correction can be introduced by reverse calculation, and if so, the procedure will be then described in the guidelines for the use of the common method(s).***
    - ***Adopt the Schall03 classification and correction for bridges.***

C14: Segmentation of the source

- ***It was decided to adopt the IMAGINE approach.***

C15: Source(s) position

In *Harmonoise/Imagine* and in *Schall03*, the rolling source is in the centre line. In Schall03, 3 source positions are defined, one on the rail for rolling source, one 4 m high for exhaust and roof equipment and one 5m high for aerodynamic noise.

- ***4 or 5 sources will be decided between specialists by e-mail, along with the corresponding positions. The 2 lowest sources are fixed according to the description in Imagine. The 3 highest sources are still under discussion, and there is an option to reduce the 4m and the 5m position to a single one.***

SOURCE SPECIFICS: INDUSTRIAL

- ***It was decided by vote that for all the items the description of sources given in IMAGINE should be used in the common method. In addition, this topic should be further discussed in an ad hoc meeting to be organised with the software developers.***

SOURCE SPECIFICS: AIRCRAFT

ECAC Doc29 database (so called ANP) is built from manufacturers' certification tests and contains aircraft specifics data. Certification tests are controlled by national authorities and EU institutions and manufacturers have to check the consistency of the measured data by comparison with their own sophisticated models.

On the contrary, *AzB* database is based on "in use" measurements on German airports and analyzed in terms of groups of aircrafts. This is supposed to be German specific (types of aircrafts in the fleet, temperature, procedures…) and may not be applied to other countries, but it is expected to be more consistent with real values since it is based on measurements.

- ***It was decided that aircraft noise issues should be further discussed in an ad hoc meeting within 2 months from the time of the present event.***
- ***It was also decided that there is a need to compare the data from the two databases (ECAC Doc 29 and AzB). There is also a need to define guidelines on how to use the software in order to reduce the discrepancy of the results produced by different users.***

3. THE WAY FORWARD

The following tasks will be performed in the period October – December 2009:

- An **ad-hoc Workshop on aircraft noise** will be organised before the end of 2009 (possibly in November 2009) for achieving consensus among the experts for the components to be used in the common noise assessment methods. The discussions should be based on ECAC doc. 29 and AzB.
- **Benchmarking/testings** should be performed **and/or ad-hoc meetings** should be organised for the following components:

  For the sound propagation part:

  - A4. '*ground effect'* (benchmark among Harmonoise/Imagine, Nord2000, NMPB)
  - A5. '*reflections*' (implementation of Nord2000 formula to be tested by software developers)
  - A6. '*diffraction & screening obstacles*' (test comparison of Harmonoise/Imagine, NMPB)

  For the road traffic source part:

  - B4. '*gradients'* (benchmark among Harmonoise/Imagine and NMPB)
  - B9, B10, B11 '*bridges, tunnels, viaducts*' (ad hoc group of road traffic noise experts of Harmonise/Imagine for investigating on the inclusion of the Japanese approach)
  - B13. '*segmentation of the source*' (ad hoc meeting with software developers and benchmarking of existing software)
  - B14. '*source(s) position*' (benchmarking and ad hoc meeting between Harmonoise/Imagine and NMPB)

  For the railway traffic source part:

  - C5. '*engine noise*', C7. '*squeel noise*', C.10 '*bridges'*, C.15 '*source position*' (ad hoc group of railway noise experts of Harmonoise/Imagine and Shall03 to discuss the implementation aspects)

  For the industrial source part:

- D1. to D4. (to be discussed in an ad hoc group among software developers)

The following tasks will be performed in the period November 2009 – April 2010:

- A **first draft of the common noise assessment methods** will be prepared **for road traffic, railway traffic and industrial noise**.

- Preparation of **good practice guidelines** for appropriate use of the common noise assessment methods should be prepared preferably in parallel with the drafting of the common noise assessment methods.

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In collaboration with EEA
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ANNEX A

Description of the components of the qualified noise assessment methods

Component / Method	**Expression / data**	**Origin**	**Testing**	**Notes**
Part of the method or dataset of the method	*Expression describing this component / or value(s) / or database used*	*How was this / formula / values / database obtained? (50 words max)*	*Was it tested against measurements (preferred) / simulations? (50 words max)*	*Any further comment (50 words max)*
A.1 - Geometrical divergence				
NORD2000	Point source: $\Delta L_d(d) = 10 \log\left(4\pi R^2/R_0^2\right)$ R = propagation distance R_0 = 1 m Line sources are modelled by a number of incoherent point sources	Classical	Not necessary	
HARMONOISE / IMAGINE	Point source: $\Delta L_{geo}(d) = 10 \cdot \lg\left(4\pi d^2/d_0^2\right)$ d = propagation distance d_0 = 1 m	Analytical formulae, solution of the wave equation for a point source / a distribution of incoherent point sources.	not to be tested	Correction Factor for propagation of spherical sound waves Explicit formula for integration over source lines increases accuracy when

	Line source (segment) $\Delta L_{geo}(d) = 10 \cdot \lg(\Delta\theta / 4\pi D)$ $\Delta\theta$ = angle of view from the receiver to the segment D = shortest distance from receiver to straight line containing the segment			using larger angles. See report IMAGINE D4.
ASJ RTN 2009	A-weighted sound pressure level L_A : $L_A=L_{WA}-8-20\ \lg(r)+\Delta L_{cor}$ $L_{WA,i}$: power level [dB] r : distance [m] ΔL_{cor}: Corrections for attenuations [dB]	[-8-20 lg(r)] (= -10 lg($2\pi r^2$)) is the geometrical spreading (inverse-square law) from an omni-directional point source in the hemi-free field	N.A.	A time history of A-weighted sound pressure level is calculated by this engineering formula. Correction terms ΔL_{cor} are applied to describe sound propagation for each source position. Methods to calculate sound propagation for each frequency component are also given in the model, which are based on wave theory (Analytical model, BEM, FDTD etc).
NMPB 2009	20 $\log_{10}$(d)+11	Physics for a point source in 3D	Not worth testing	
RVS				
Schall 03	$A_{div} = 10\ \lg\left(\frac{4\pi d^2}{d_0^2}\right)$ dB	See ISO 9613 - 2		See ISO 9613 - 2
AzB 2008	$D_S(s) = -10 \cdot \lg(4\pi s^2 / s_0^2)$ s = propagation distance s_0 = 1 m	classical formula	not to be tested	Correction Factor for propagation of spherical sound waves
ECAC Doc. 29	Standard spherical divergence, combined in NPD data in			

	database			
A.2 - Atmospheric absorption				
NORD2000	Effect of air absorption ΔL_a is calculated by $A_0 = \alpha(f_0)R$ $\Delta L_a = -A_0\left(1.0053255 - 0.00122622\ A_0\right)^{1.6}$ A_0 = absorption according to ISO 9613-1 at 1/3 octave band centre frequency f_0 $\alpha(f_0)$ = attenuation in dB/m at frequency f_0 R = propagation distance	ISO 9613-1 with conversion to 1/3 octave bands by Joppa et al	Not necessary	
HARMONOISE / IMAGINE	$\Delta L_{air}(d) = \alpha(f)..d$ d = propagation distance α = absorption coeff..	Air absorption coefficients calculated as a function of temperature and humidity according to ISO 9613-1. Analytical formula for molecular damping	not to be tested	For strategic noise maps, it is acceptable to use 70%, 15°C as default values.
ASJ RTN 2009	Yes $\Delta L_{\text{air}} = -6.84(r/1000) + 2.01(r/1000)^2 - 0.345(r/1000)^3$	ISO 9613-1:1993 Temperature: 20 degrees, Relative humidity: 60%. Vehicle noise spectrum	No The formula was obtained from a numerical simulation	[ISO 9613-1:1993] is applied for arbitrary temperature and relative humidity condition.
NMPB 2009	table	ISO 9613-1 for fixed T	Not worth testing	

		and moisture		
RVS				
Schall 03	$A_{atm} = \frac{\alpha d}{1000}$	See ISO 9613		With α for temperature of 10 °C and 70 %; see ISO 9613 - 2
AzB 2008	$D_{L,\mathrm{n}} = -d_{\mathrm{n}} \cdot \frac{s}{s_0}$ s = propagation distance s_0 = 1 m d_n = absorption coeff.. n = octave band No.	classical formula	not to be tested	absorption coefficients close to SAE ARP 866 / ISO 3891 values for 15°C and 70%RH (exact source unknown - not changed since first release of AzB in 1975)
ECAC Doc. 29	Average airport absorption coefficients as described in Doc. 29 Vol. 2 Appendix D	Based on reported atmospheric conditions at a number of airfields used for noise certification over several decades	See left.	Ability to replace default average airport absorption coefficients with coefficients relating to a specific temp/RH
A.3 - Terrain profile				
NORD2000	Digital terrain model or vertical terrain cross-section in 2D cases is required			The cross-section from the source to the receiver is described by a sequence of line segments. Each segment is assigned an impedance value (and optionally an unevenness value). Barriers and buildings are considered part of the terrain profile.
HARMONOISE / IMAGINE	Digital terrain model required	-	Experimental : - Harmonoise WP4	The cross-section from the source to the receiver is described by a sequence of

			- Imagine WP7 - Météore (heavy weapons shooting noise over long distances - confidential) Numerical : - Harmonoise WP2 : more than 10.000 calculations with reference models are stored in a (publicly available) database. - Comparisons with Nord 2000 (see liitterature) - Comparisons with NMPB 2008 (ongoing)	line segments. Each segment is assigned an impedance value. There is no distinction between ground, screens and buildings, all are described in a unified way.
ASJ RTN 2009	Yes $\Delta L_{\mathrm{diff,suffix}}=\Sigma(f(\delta))$ ΔL_{diff}: Correction due to acoustical obstacles suffix: Type of obstacles (embankment, etc.) $f(d)$: single diffraction effect [dB] δ: path difference [m]	Meakawa's experimental chart & Vehicle noise spectrum	Yes The formula was obtained from experimental data.	Terrain profile is treated as acoustical obstacle. The sound attenuation is calculated by setting a hypothetical barrier with thickness in place of obstacle such as embankment.
NMPB 2009	Least square estimate of the profile of altitudes. Possibly 2 if diffraction	Arbitrary choice	No unit test, difficult to test in itself. Overall testing of the method with respect to experiment (6 campaigns) or reference	

			methods (BEM or PE).	
RVS				
Schall 03	Digital terrain model			
AzB 2008	digital terrain model required	-	not to be tested	change of propagation geometry due to terrain elevation
ECAC Doc. 29	Accounts for change in geometry (slant distance and elevation angle)	Based on basic propagation theory	n/a	
A.4 - Ground effect				
NORD2000	Ray model, formula by Chien and Soroka Delany and Bazley impedance model Impedance classes A-H	Analytical	Validated by measurements and theoretical models including Harmonoise benchmark cases.	Other impedance models may be used by the Nord2000 method but officially only Delany and Bazley is used
HARMONOISE / IMAGINE	Analytical formula established by Chien and Soroka Input = impedance values, impedance models (Delany-Bazley, Hamet,…), impedance classes (A to F, as in Nord 2000).	Analytical	Well accepted since first published in the late ’70. Basis for NMPB 96, Nord 2000, revision of TNM,…	The Harmonoise P2P model calculates the excess attenuation ΔL_{excess}, which is a combination of reflection on the ground, diffraction by screens and terrain and meteorological refraction. For strategic noise maps a simplified classification is proposed.
ASJ RTN 2009	Yes $\Delta L_{grnd}=K\lg(r/r_0)$ for $r>r_0$ $K=f(h_s, h_r, d, \sigma)$	Wave theory (Thomasson) & Vehicle noise spectrum	Yes The formula was obtained from numerical computer	Parameters K and r_0 are given by tables and regression formula.

	$r_0=g(h_s, h_r, d, \sigma)$ h_s: source height, h_r: receiver height, d: distance; σ: effective air flow resistivity		simulation based on wave theory. The validity is checked by outdoor experiments	For calculation of each frequency component, Chien and Soroka formula applies. Numerical simulation by BEM and FDTD is also applicable.
NMPB 2009	Too complicated to place in a cell of spreadsheet ! See 7.3 of the method.	Defrance et al. Applied Acoustics 1999 + Dutilleux et al. Submitted for publication Acta Acustica	Ray theory (Propate LCPC). Propate is based on l'Espérance et al. Appl. Acoust. 1992 + Overall testing of the method with respect to experiment (6 campaigns)	Complete description of the method in: F. Besnard et al., *Road noise prediction: 1 - Calculation of road traffic noise emission*. SETRA, sept. 2009 and G. Dutilleux et al. *Road noise prediction - 2: NMPB 2008 - Noise propagation computation method including meteorological effects*. SETRA, sept. 2009 Available on *(http://trfgd.free.fr/nmpb2008_en_21082009.pdf)*
RVS				
Schall 03	$A_{gr} = \left[4{,}8 - \frac{2\,H_m}{d}\left(17 + \frac{300\,d_0}{d}\right)\right]$ dB ≥ 0 dB	See ISO 9613		Not frequency – selected as there are not plausible values; see ISO 9613-2, (10)
AzB 2008	$D_{Z,\mathrm{n}}(s,\alpha) = -D_{Z,0,\mathrm{n}}(s)\cdot\Delta(\alpha)$ with	Empirical formula, resulting absorption up to	Formula is a fit to spectral measurements of jet noise	The fomula provides nearly the same attenuation values as the empirical

	$D_{Z,0,n} = \frac{G_n \cdot s/s_1}{\sqrt{1+(s/s_1)^2}}$ s = propagation distance s_1 = 700 m G_n = ground absorption coeff.. n = octave band No. $\Delta(\alpha) = 1 - \sin(\alpha)$ (for elevation angles α between 0 and 15°)	10dB in A-weighted level.	propagation close to the ground (peformed by Parkin and Scholes in 1964/1965). Algorithm has not changed since first release of AzB in 1975.	formula that was implemented in the Swiss FLULA model.
ECAC Doc. 29	AIR-5662	Based on AIR-1751, which itself was based on Parkin and Scholes theory.	Tested in NASA 2000-CR-210111	
A.5 - Reflections				
NORD2000	Contribution of a reflection path is added incoherently to the contribution of the direct path and corrected for the loss at the reflection according to $\Delta L_r = 10 \log(\rho_E(f)) + 20 \log\left(\frac{S_{refl}(f)}{S_{Fz}(f)}\right)$ ρ_E(f) = energy reflection coefficient Second term is a correction for finite dimensions of the surface based on Fresnel zone considerations	Semi-empirical	Not considered necessary	
HARMONOISE / IMAGINE	From all “almost” vertical surfaces : walls, façades, screens,…		Comparison with numerical models	Default values for noise barriers depending on acoustical classification

	Reflection / absorption coefficients for noise barriers. Finite dimensions corrected for by means of Fresnel weighting		Experimental - scale models - validation of NMPB 96 in urban situations - Imagine WP7	DL_{α}
ASJ RTN 2009	Yes ΔL_{refl}	Mirror image source method for flat surface Lambert's cosine law for uneven surface	No	Reflection surface with finite size such as rectangular plane can be treated
NMPB 2009	On the ground : ground effect see A4. On other obstacles: absorption coefficient and specular reflection	Classical theory of geometrical acoustics	No testing	
RVS				
Schall 03	ISO 9613 -2, Chap. 7.5; max. 3 reflections;	See ISO 9613		In addition, the reduced sound insulation of reflecting noise barriers (e.g. transparent barriers) is considered
AzB 2008	-	-	-	Not taken into account for aircraft noise calculation
ECAC Doc. 29	Not considered			
A.6 - Diffractions / screening obstacles				
NORD2000	The Hadden-Pierce ray solution for a wedge with finite impedances faces is used for single screens. The Hadden-Pierce solution is based on ray path distances and diffraction angles.	Semi-analytical based on Hadden-Pierce, Jonasson, and Salomons	Validated by measurements and theoretical models including Harmonoise	Only diffraction of the two most efficient edges are included in Nord2000 The basic solution is for an infinite

	When the screen is placed on a ground surface the image method proposed by Jonasson is used with diffraction by Hadden-Pierce and ground effect by Chien and Soroka. For multiple screens or screen with multiple edges the semi-analytical approach of Salomons has been adopted based on Hadden-Pierce		benchmark cases.	screen. Finite screens are handled by adding extra propagation paths around the screen ends corrected for the diffraction of the vertical edges
HARMONOISE / IMAGINE	Degout's approximation of Frensel integrals gives attenuation as a function of path length difference and wavelength. Analytical prolongation of path length difference for sources / receivers (very) deep in the shadow zone. Reflections from the faces of wedges / thick barriers are taken into account as ground effects.	Approximation of complex integral first established for EM wave propagation.	Comparisons with numerical models & analytical formulas (Kirchhoff, Hadden & Pierce, Kouyiamjan,…)	Both horizontally and vertically. Finite dimensions are corrected for by means of Fresnel weighting in order to guarantee continuity of results as the barrier's length or height tends to zero. In case of multiple barriers, the total effect of diffraction is calculated in a recursive way. Any combination of thin screens, wide barriers and shielding by terrain, up to any number, can be taken into account.
ASJ RTN 2009	Yes (Same as A.3) $\Delta L_{\mathrm{diff,suffix}}=\Sigma(f(\delta))$ suffix: type of noise barriers (single, double, triple, finite length, edge modified....,)	Meakawa's experimental chart & Vehicle noise spectrum	Yes The formula was derived from experimental data. Validity for some types noise barriers including	The numerical expression for Maekawa's chart and the application to road traffic noise is available. For example, a next expression is given. ΔL_{d}=a+b*sinh$^{-1}(c_{\mathrm{spec}}\ \delta)^{0.414}$.

			edge modified noise barriers has been checked.	c_{spec}: parameter dependent on type of noise spectrum
NMPB 2009	Too complicated to place in a cell of spreadsheet ! See 7.4 of the method.	Defrance et al. Applied Acoustics 1999 + Dutilleux et al. Submitted for publication Acta Acustica, 2009)	BEM (P. Jean, JSV 1998) + Overall testing of the method with respect to experiment (6 campaigns)	
RVS				
Schall 03	ISO 9613 – 2; Chap. 7.4; with C2 = 40	See ISO 9613		The multiple diffraction of more then 3 edges is considered following the rubberband method
AzB 2008	-	-	-	Not taken into account for aircraft noise calculation
ECAC Doc. 29	Not obstacles considered.			Not relevant for aircraft noise except where aircraft on ground close to runway, which is normally inside important zones being considered
A.7 - Modelling of meteorological influence (consider the effect of temperature, pressure, wind speed and direction)				
NORD2000	Meteorological conditions are included by curving the rays in the basic ground reflection and diffraction ray models in order to model the refraction effect of the vertical effective sound speed profile.	The “heuristic model” approach proposed by L’Espérance has been used but with a modified linearization principle for	Validated by measurements and theoretical models including Harmonoise benchmark cases.	For the prediction of yearly average of Lden and Lnight the approach developed in the Harmonoise project based on 25 meteorological classes has been adopted.

	Nord2000 specifies that the vertical effective sound speed determined on basis of thevertical temperature profile and wind speed component profile in the direction of propagation has to be approximated by a log-lin profile c(z): $$c(z) = A \ln\left(\frac{z}{z_0} + 1\right) + B z + C$$ z = height above ground z_0 = ground roughness length A, B, C are constants However, in the Nord2000 method the log-lin profile is converted into an equivalent linear sound speed profile in which case the rays conveniently will be arcs of circles.	the equivalent linear sound speed profile and with an extension to diffraction cases developed within the Nord2000 project.	Yearly average of Lden has been validated by comparison with Harmonoise WP2 reference model calculations ("Test calculations of day-evening-night levels")	When developing meteo-statistics for the Nordic countries it was found that occurrences seldom were found in more than 9 classes. In Denmark where Nord2000 has been introduced as the official method for road and railway noise and used for the strategic noise mapping of 2006 it was found that the number of meteo-classes could be reduced to 4 for noise mapping purposes and it was recommended to use only 1 class for city areas (neutral weather).
HARMONOISE / IMAGINE	Specific conditions are described by means of vertical profiles of wind speed, wind direction and temperature. From these, the sound speed profile c(z) is calculated. The profile is approximated by means of a Lin-Log function. The lin-log function is transformed into an equivalent linear gradient / ray curvature. Ray curvature "R" is taken into account by means of conformal mapping of the cross section (ground + obstacles). On the transformed cross section, the standard P2P model for homogeneous atmosphere is applied.	Scientific progress made in the past 20 years : L'Espérance, Daigle, Gabillet, Defrance, Premat,…	Numerical : comparison with PE models Scale models Measurements Harmonoise WP4 Imagine WP7	The model can use a large variety of meteorological input data : i.e. data from : – weather stations – meteo forecast – meteorological models – surface observation – meteo towers – balloons – aircraft

				For the prediction of LDEN and Lnight on a yearly averaged basis, the ray-curvature are calculated over 1 year and classified in "propagation classes". Depending on situations, 1 to 4 classes are required to estimate the yearly average value of LDEN and Lnight. Local statistics are easily derived from climatological databases, e.g. ERA15 or ERA40 published by the European Center for Meteorology and Weather Forecast. As a default, the guidelines from AR-INTERIM can be used.
ASJ RTN 2009	Yes $\Delta L_{m,line}=0.88\lg(l/15)U_{vec}$ l: horizontal distance [m] U_{vec}: vector wind [m/s]	Outdoor survey data	Yes The formula was obtained from road traffic noise measurement data	The correction applies to show the possibility of variation for LAeq under a certain wind condition.
NMPB 2009	2 classes of meteorological conditions : homogeneous and downward-propagation conditions.+ probability of occurrence of downward-refraction conditions for each	Micro-meteorological model Choisnel (Brunet et al. LRSP 1996) +	"Mid-term" levels from overall testing of the method with respect to	

	source-receiver direction	parabolic equation (Ecotière et al. To be published 2009)	experiment (6 campaigns)	
RVS				
Schall 03	ISO 9613 – 2 with Kmet = 0	See ISO 9613		
AzB 2008	Average propagation conditions assumed (isotropic atmosphere, 15°C, 70% RH, no wind).	-	Comparison with simulations of real atmospheric conditions showed good agreement for long-time-Leq (DLR project Quiet Air Traffic)	
ECAC Doc. 29	Effect of wind and temperature on source emission and location accounted for using Doc. 29 Vol. 2 Appendix B Effect of temperature and relative humidity on propagation accounted for using Doc. 29 Vol. 2 Appendix D. Effect of wind on propagation not considered.	Effects on source based on fundamental performance theory.	Validated against manufacturers performance data. See NASA 2006-CR-214511.	The effects of wind on propagation are only important close to the ground. At altitude, the primary effect is on change in location of the source. For example see ERCD Report 0207 Figures 37, 38 (www.caa.co.uk/ercdreport0207)
ROAD SPECIFIC				
B.1 - Classification of vehicles				
NORD2000	3 vehicles categories: passenger cars, medium heavy (two axles), and heavy vehicles (3 or more axles). A correction for the number of axles is included for heavy vehicles			
HARMONOISE / IMAGINE	4 main classes	Nord 2000		

ASJ RTN 2009	Yes 5 category classification			Motorcycle is newly included in ASJ RTN-Model 2008.
NMPB 2009	LV and HGV	Large set of pass-by measurements over 10 years	Statistical analysis	(Hamet et al. accepted for publication Appl. Acoust. 2009)
RVS				
Schall 03	--			
AzB 2008	--			
B.2 - Speed dependence				
NORD2000	Yes, separately for tire/road and propulsion noise using the Harmonoise equations			
HARMONOISE / IMAGINE	Yes, separately for traction noise and rolling noise			
ASJ RTN 2009	Yes a+30lg(*V*): steady traffic flow b+10lg(*V*): non-steady traffic flow *V*: running speed [km/h] a,b: coefficients	An empirical model applies. The formula was deduced from test track experiments.	Yes Field measurements at streets and highways are used to determine the coefficients.	30lg(*V*) applies to expressways. 10lg(*V*) applies to general roads. The selection depends on the speed of vehicles as well as traffic flow condition.
NMPB 2009	A+Blog(V) A and B depend on vehicle class, pavement type, age of pavement	From statistical pass-by measurements and further statistical analysis	Statistical analysis	(Hamet et al. accepted for publication Appl. Acoust. 2009)
RVS				
Schall 03	--			

AzB 2008	--			
B.3 - Acceleration/deceleration (Traffic flow)				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes, continuous correction on traction noise			
ASJ RTN 2009	Yes The formula a+30log(V) or b+10lg(V) applies a,b: coefficients	An empirical model applies. The formula was deduced from test track experiments.	Yes Field measurements at streets and highways are used to determine the coefficients.	10lg(V) applies in accelerating, 30lg(V) in decelerating.
NMPB 2009	DeltaL depends on gradient	From statistical analysis of pass-by measurements	Statistical analysis	(Hamet et al. accepted for publication Appl. Acoust. 2009)
RVS				
Schall 03	--			
AzB 2008	--			
B.4 - Gradients				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes, equivalent to acc/dec			Speed variation of HGV on long ramps is not modelled automatically and left to the end-user (change of input parameters)
ASJ RTN 2009	Yes (heavy vehicle) $\Delta L_{grad}=0.14i_{grad}+0.05i^2_{grad}$ $0<i_{grad}<i_{grad,max}$	An approximate expression based on a theoretical model.	No	Correction applies only to heavy vehicles.

NMPB 2009	DeltaL depends on gradient	From statistical analysis of pass-by measurements	Statistical analysis	(Hamet et al. accepted for publication Appl. Acoust. 2009)
RVS				
Schall 03	--			
AzB 2008	--			
B.5 - Road surface type correction				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	Yes ΔL_{surf} applies to drainage asphalt pavements V<60km/h ΔL_{surf}=a+b*lg(y+1) V>60km/h ΔL_{surf}=c+d*lg(V) +e* lg(y+1) a-e : coefficients y :years after the pavement is first laid.	An empirical model applies. The formula was deduced from test track experiments.	**Yes** Coefficients were determined by measurements at streets and highways. Long term noise monitoring was carried out to obtain the acoustical durability of drainage asphalt pavement.	Acoustical durability of drainage asphalt pavement is taking into account in the model. The correction against the duration is up to 15 yeas for expressway and 7 years for general public roads.
NMPB 2009	3 pavement types and 2 age classes => A and B in B.2	From statistical analysis of pass-by measurements	Statistical analysis	(Hamet et al. accepted for publication Appl. Acoust. 2009)
RVS				
Schall 03	--			

AzB 2008	--			
B.6 - Tyre type correction				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	No			
NMPB 2009	Not relevant at the scale of a whole country.			Data difficult to obtain
RVS				
Schall 03	--			
AzB 2008	--			
B.7 - Engine noise/Exaust noise				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	No			
NMPB 2009	Lw=Lrolling + Lengine	From statistical analysis of pass-by measurements (Hamet et al. accepted for publication Appl. Acoust. 2009)	Statistical analysis	Exhaust noise is not specifically considered.
RVS				
Schall 03	--			
AzB 2008	--			
B.8 - Aerodynamic noise				

NORD2000	No			
HARMONOISE / IMAGINE	No			
ASJ RTN 2009	No			
NMPB 2009	Not relevant			Negligible below usual speed limits
RVS				
Schall 03	--			
AzB 2008	--			
B.9 - Bridges				
NORD2000	No			
HARMONOISE / IMAGINE	No			Propagation effects are taken into account for all noise sources on top of the bridge
ASJ RTN 2009	Yes Same as B.11	Same as B.11	Same as B.11	Same as B.11 A large scale bridge structure such as truss bridge is out of scope.
NMPB 2009	Nothing foreseen			
RVS				
Schall 03	--			
AzB 2008	--			
B.10 - Tunnels				
NORD2000	No			
HARMONOISE / IMAGINE	No			Standard solution: equivalent noise sources at the tunnel mouths. See GPG.

ASJ RTN 2009	Yes	An imaginary point source and a plane source are assumed in a tunnel. Test site data and field measurements at highway tunnels are the background.	Yes The validity was checked by field measurements	Tunnel shape with hemicycle and rectangular are treated in the model. Absorptive treatment inside wall of the tunnel is possible.
NMPB 2009	Equivalent source			Also for trenches and partial covers
RVS				
Schall 03	--			
AzB 2008	--			
B.11 - Viaducts				
NORD2000	No			
HARMONOISE / IMAGINE	No			Dito bridges.
ASJ RTN 2009	Yes (only to heavy vehicle) The noise unique to viaduct "Structure borne noise of Viaduct" applies.	A hypothetic moving point source model applies. Test site data and field measurements at highway viaducts are used to the modeling.	Yes The validity was checked by field measurements	There are 5 categories of road viaduct. The power level of structure borne noise is given by $L_{WA,\mathrm{str}}$=a+30lg(V).
NMPB 2009	Nothing foreseen			
RVS				

Schall 03	--			
AzB 2008	--			
B.12 - Crossings				
NORD2000	No			
HARMONOISE / IMAGINE	No			Change of input parameters (speed, acc/dec) left to the end-user and/or by means of coupling with traffic modelling
ASJ RTN 2009	Yes	Two separated road model and a model based on dynamic simulation applies.	Yes The validity was checked both by computer simulations and field measurements	For signalized intersection, signal phase (green and red light) is also a parameter.
NMPB 2009	Specific emission values for low speed, unstable traffic flow type			
RVS				
Schall 03	--			
AzB 2008	--			
B.13 - Segmentation of the source				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes			Depends on : - integration technique - ray path algorithm - accuracy requirements See annexes in IMAGINE D4

				Guidelines and settings may depend on purpose of the calculation (strategic noise maps / action planning)
ASJ RTN 2009	Yes (It is possible)			
NMPB 2009	Equidistant or equiangular	Numerical simulations	Comparison with analytical results for a continuous incoherent line source.	
RVS				
Schall 03	--			
AzB 2008	--			
B.14 - Source(s) position				
NORD2000	Yes, one line source per lane with normally 3 source heights			
HARMONOISE / IMAGINE	Yes In principle: 1 line source per lane, 3 superposed source heights. However, this can be largely reduced depending on accuracy requirements. E.g. findings IMAGINE WP1: one source line for the whole road is OK for strategic noise mapping.			See IMAGINE report D8 for sensitivity analysis. Differentiation of traffic per lane is more important than separation of source lines with identical sound power! If one wants the full accuracy of the method, than lanes should be modelled by means of separate line sources, but each line source should be given separate traffic data: more trucks on the extreme lanes / higher speeds on the central lanes.
ASJ RTN 2009	Yes	Based on sound intensity	No	Considering the sound reflection from

	All sources are assumed to be located at 0 m above the road surface	measurements for source identifications	The source location was not directly checked at streets and highways.	the road surface, the height 0m is the centre of the noise energy emission.
NMPB 2009	0.05 m	From an interference method (Gaulin, PhD 2000) and array processing	Long range sound propagation simulations	
RVS				
Schall 03	--			
AzB 2008	--			
RAILWAY SPECIFIC				
C.1 - Wheel roughness				
NORD2000	No			
HARMONOISE / IMAGINE	Yes			Measured values or generic values based on classification
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes Correction dependent on the octave band	Theoretical model on the basis of data of noise measurements of pass-byes of about 10000 trains, $L_{W'A,f,h,m,Fz} = a_{A,h,m,Fz} + \Delta a_{f,h,m,Fz} + 10\lg\frac{n_Q}{n_{Q,0}}\mathrm{dB} + b_{f,h,m}\lg\left(\frac{v_{Fz}}{v_0}\right)\mathrm{dB} + \sum c_{f,h,m} + \sum K$ $a_{A,h,m,Fz}$ A-weighted sum sound level of the length-related sound power at the reference speed $v_0 = 100$ on a sleeper track with an average condition of the rail surface, in dB, $\Delta a_{f,h,m,Fz}$ Level difference in the octave band f in dB,		

		n_Q Number of sound sources of the vehicle unit , $n_{Q,0}$ Reference number of sound sources of the vehicle unit, $b_{f,h,m}$ Speed factor, v_{Fz} Speed, v_0 Reference speed, $v_0 = 100$ $c_{f,h,m}$ Level corrections for type of track and rail surface, K Level corrections for bridges and nuisance of noises;		
AzB 2008	--			
C.2 - Rail roughness				
NORD2000	No			
HARMONOISE / IMAGINE	Yes			Measured values or generic values based on classification
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes Correction dependent on the octave band			In addition, correction for rail grinding
AzB 2008	--			
C.3 - Classification of vehicles/ locomotives				
NORD2000	No, only specific train types			
HARMONOISE / IMAGINE	Yes			Rolling stock = combination of elementary sources taken from the generic database.

				Work started in IMAGINE WP6. Not finished for all European rolling stock.
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes 7 types of powered vehicles and 3 types of unpowered vehicles and 2 types for trams			Acoustic datas also for noise sources in shunting yards, container-terminals
AzB 2008	--			
C.4 - Rolling noise / speed dependence				
NORD2000	The speed dependence is determined by measurements of the total noise			
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes -5 to +25 dependent on the octave band -5 lower octave bands / 25 higher octave bands			
AzB 2008	--			
C.5 - Engine noise / speed dependence				
NORD2000	The speed dependence is determined by measurements of the total noise			

HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes 20*log v/v0 (v0 = 100 km/h)			In addition aggregate noise
AzB 2008	--			
C.6 - Aerodynamic noise / speed dependence				
NORD2000	No			
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes 50*log v/v0 (v0 = 100 km/h			
AzB 2008	--			
C.7 - Squeal noise				
NORD2000	No			
HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			

RVS				
Schall 03	Yes Correction of 3 or 8 dB(A) for a radius < 500 m			
AzB 2008	--			
C.8 - Braking noise				
NORD2000	No			
HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes In railway stations a minimum speed of 70 km/h is to be applied;			
AzB 2008	--			
C.9 - Track/support structure classification				
NORD2000	No			
HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes Ballasted tracks with sleeper,			

	slap tracks slap tracks with absorbent covers			
AzB 2008	--			
C.10 - Bridges				
NORD2000	No			
HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes; dependent on the construction between 4 to 12 dB(A)			
AzB 2008	--			
C.11 - Tunnels				
NORD2000	No			
HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	No			
AzB 2008	--			
C.12 - Viaducts				
NORD2000	No			

HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	No			
AzB 2008	--			
C.13 - Crossings				
NORD2000	No			
HARMONOISE / IMAGINE	?			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes correction of octave band for reflection and rail-roughness			
AzB 2008	--			
C.14 - Segmentation of the source				
NORD2000	Yes			
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				

Schall 03	Yes			
AzB 2008	--			
C.15 - Source(s) position				
NORD2000	Yes, three source heights in most of the frequency range			
HARMONOISE / IMAGINE	Yes			Very important: integration of sources in surrounding terrain. Reference of the source model = head of track, but where is the track in relation to the terrain? Because of the change in "scale", this data cannot be found in GIS.
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	Yes Three positions 0 m, 4 m, 5 m			
AzB 2008	--			
INDUSTRIAL SPECIFIC				
D.1 - Point source definition				
NORD2000				Source specific guidelines has not been elaborated yet for industrial noise sources but the propagation model is assumed to be applicable
HARMONOISE / IMAGINE	Yes			

ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	--			
D.2 - Line source definition				
NORD2000				
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	--			
D.3 - Area source definition				
NORD2000				
HARMONOISE / IMAGINE	Yes			
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	--			
D.4 - Sound power and directivity (database)				

NORD2000				
HARMONOISE / IMAGINE	Yes			The database can be used with ANY propagation model and should not be considered integral part of the method. Can become part of the GPG.
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	--			
AIRCRAFT SPECIFIC				
E.1 - Segmentation (function of aircraft performance and track)				
NORD2000				Source specific guidelines has not been elaborated yet for aircraft but the propagation model is assumed to be applicable
HARMONOISE / IMAGINE	ECAC Doc.29			No specific development in Harmonoise/Imagine. Doc.29 handles this with sufficient detail and accuracy. The aim of Imagine project was to provide an alternative to Chapter 4 of Vol, " Noise calculation for a single event"
ASJ RTN 2009	--			

NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	3-step-segmentation: (1) curved track segments to chords (2) combination with segmented flight profile (3) segmentation based on characteristic emission (change in sound power level must be less 1dB between adjacent segments)			This segmentation is a preprocessing step. An additional segmentation step based on the source-observer geometry is performed during the process of immission calculation
ECAC Doc. 29	Method described in Doc.29 Vol. 2 Chapter 3.	Evolved from earlier edition.	Updated method based on comparison with 1 second long segments, optimised to give similar answer with significantly faster computation.	
E.2 - Aircraft performance and flight profile as a function of air parameters, aircraft type, engine type, TOW (database)				
NORD2000				Source specific guidelines has not been elaborated yet for aircraft but the propagation model is assumed to be applicable
HARMONOISE / IMAGINE	ECAC Doc.29			No specific development in Harmonoise/Imagine. Doc.29 handles this with sufficient detail and accuracy. The aim of Imagine project was to

				provide an alternative to Chapter 4 of Vol, “ Noise calculation for a single event”
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	Only fixed profiles for aircraft categorys. No explicit parameter for engine power – power changes are modeled by source level in-/decreases.	Profile data are for one characteristic aircraft representing an aircraft group. They do not describe each aircraft in this group.	Immission data were validated by comparison with measurements of aircraft noise monitoring systems at German airports => national database!	The AzB is a model based on the concept of acoustic equivalence (aircraft producing similar noise footprints can be grouped). Exact flight path modelling is not intention of the AzB.
ECAC Doc. 29	Based on fundamental flight mechanics theory, taking into account change of lift, drag and thrust with, temperature, speed and altitude. Linked to ANP database that provides aerodynamic and thrust parameters required.	Based on fundamental theory, verified against manufacturers performance models.	Validated against manufacturers performance data. See NASA 2006-CR-214511. Adhoc testing undertaken by model users.	
E.3 - Aircraft noise as function of performance (database)				
NORD2000				Source specific guidelines has not been elaborated yet for aircraft but the propagation model is assumed to be

				applicable
HARMONOISE / IMAGINE	Yes			Reverse engineering of ANR in order to derive spectral / directional sound powers
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	See E.2 and E.4			
ECAC Doc. 29	NPD data defines change in noise level as a function of source power (thrust) and slant distance.	Data provided by manufacturers.	Adhoc testing undertaken by model users. See ref 167 in main document	Sometimes criticised for integrating source power and propagation effects. But, by holding either parameter constant the separate effects of source emission vs thrust or source emission vs slant distance are clear.
E.4 - Source directivity				
NORD2000				Source specific guidelines has not been elaborated yet for aircraft but the propagation model is assumed to be applicable
HARMONOISE / IMAGINE	Yes			Generic values for different aircraft types – taken from FLULA, based on measurements around Swiss airports.
ASJ RTN 2009	--			

NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	Reference spectra and coefficients for multipole description of directivity.	Lots of sources (measurements, manufacturers etc.), documented only internally.	Only A-weighted levels were explicitely tested.	Spectra and directivity coefficients are derived from a subset of spectral and directivity classes (usually based on engine type). Database should be updated.
ECAC Doc. 29	Based on 4th power 90 degree dipole	Approximately accords with empirical engine directivity data.		
E.4b Engine shielding and scattering/refraction ECAC Doc. 29	Empirical relationships taken from AIR-5662.	Derived from full scale flight tests using Boeing 767-400, DC-9 etc.	Based on flights tested reported in NASA-2003-TM-212433.	See earlier comments, this is an important aspect of aircraft noise, often considered part of source directivity, but in fact accounts for how propagation of engine noise around aircraft structure and through aircraft flow fields affects propagation of the source.
E.5 - Dispersion of tracks				
NORD2000				Source specific guidelines has not been elaborated yet for aircraft but the propagation model is assumed to be applicable
HARMONOISE /	Yes			Dito Doc.29

IMAGINE				
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			
AzB 2008	Modelling by 15 subtracks.		15 segments is a best-practice-value resulting e.g. from simulations	
ECAC Doc. 29	Based on traffic distributed across a number of dispersed tracks. See Doc. 29 Vol. 2 Appendix C.	Derived from theoretical assessment of dispersion required to equate to a normal distribution.	Tested against individual flight tracks.	In the absence of local dispersion information, default dispersion data provided to define spacing of dispersed tracks for modelling.
E.6 - Ground operations				
NORD2000				Source specific guidelines has not been elaborated yet for aircraft but the propagation model is assumed to be applicable
HARMONOISE / IMAGINE	Yes			The Harmonoise P2P model is continuous for sources close to the ground / in the air / above the receiver.
ASJ RTN 2009	--			
NMPB 2009	--			
RVS				
Schall 03	--			

AzB 2008	Taxiing and APU operations included. Taxiing modeled by segmentation, APU by omnidirectional point sources.	APU-data derived from measurements		Modelling of taxiing is very time consuming but does not give significant contributions to total noise. More or less a political issue.
ECAC Doc. 29	Accounts for air noise, i.e. noise generated during takeoff and landing, but not taxi or engine run-up operations			

ANNEX B

Workshop's agenda

Tuesday - 8 September 2009 *Building: Committee of Regions, JDE70 (room)* *Committee of Regions, Batiment Jacques Delors,* *Rue Belliard 99-101, B 1040 - Bruxelles*		
9:30-10:00	Introduction by DG JRC, DG ENV and EEA	*Stylianos Kephalopoulos* *Marco Paviotti* *Fabienne Anfosso-Ledee* *Balazs Gergely* *Colin Nugent*
10:00	Presentation on the requirements of the common methods	
10:45	coffee break	
11:00	Discussion on the elements of the common noise assessment methods - (PROPAGATION part I)	
13:00	Lunch	
14:00	Discussion on the elements of the common noise assessment methods - (PROPAGATION part II)	
16:15	coffee break	
16:30	Discussion on the elements of the common noise assessment methods - (SOURCE part for AIRCRAFT)	
18:00	End of the 1st day Workshop	

Wednesday - 9 September 2009 *Albert Borschette Building, AB-3D* *Rue Froissart 36, 1049 - Bruxelles*		
9:30	Discussion on the elements of the common noise assessment methods - (SOURCE part for ROAD)	
10:45	coffee break	
11:00	Discussion on the elements of the common noise assessment methods - (SOURCE part for RAILWAY)	
13:00	Lunch	
14:00	Discussion on the elements of the common noise assessment methods - (SOURCE part for INDUSTRIAL)	
15:30	coffee break	
15:45	General conclusions, follow-up work, and deadlines	
17:30	End of the 2nd day Workshop	

ANNEX C

List of Workshop participants

DG JRC – DG ENV –EEA Workshop

on

"Selection of common noise assessment methods in EU"

8-9th September 2009, Brussels

List of Participants

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