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Harmonised **A**ccurate and **R**eliable **M**ethods for the EU Directive on the Assessment and Management **O**f Environmental **Noise**

WP1.2 Rail Sources

Categorisation of vehicles and tracks: overview and draft proposal

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Contents

1 Introduction & Objectives

The WP1.2 objective is to develop an accurate description of railway noise sources that will be the basis for the input to the Harmonoise engineering model.
This document gives an overview of the different categorisations that already exist in calculation schemes and those which have been provided by the STAIRRS project. The report summary is a starting point for a categorisation proposal that will be further detailed in the next tasks of WP1.2 (database structure and conclusions on sources knowledge).
Railway traffic is a complex sound source that needs to be simplified for this purpose. It will be described in terms of equivalent sources determined from physical sources. A model built from these equivalent sources will be determined and a database structure will be defined. The practical methods to obtain model parameters and at the end sound power levels in third octave bands will be specified.
In order to avoid excessive measurements for each vehicle and track type, a categorisation for tracks and vehicles based on physical parameters is useful. This will cut the need to make measurements for each train type; only those trains for which existing categories are not convenient will require measurements.

2 Existing categorisations

2.1 France

In France, a categorisation has been proposed as a part of a French legislation on "surface transport acoustic classification" [1]. Categorisation is based on different types of trains and different track designs.

2.1.1 Train categories

These categories are based on the type of train and for some of them, subcategories have been defined to take into account different generations of the same train type or design modifications affecting noise emission. For each subcategory, speed, length and reference levels are specified.
The following train categories are defined in the legislation:

Categories	Subcategories
Short urban and suburban trains	• Three categories of suburban trains (different speeds and designs) • Metro
Passenger trains	• Conventional passenger trains • High speed trains (TGV) first generation second generation
Freight trains	For freight trains or conventional passenger trains a correction can be applied for taking into account a modification of the length
Single units	Railcars and bi-coaches electric railcars

In some cases, more subcategories can be used, e.g. for TGV, the types Eurostar, TGV Duplex, TGV Réseau and Renovated TGV PSE. These categories are used in the MITHRA-FER propagation software in which case "coach types" (e.g. TGV power car, end coach, middle coaches) can also be taken into account.

2.1.2 Track categories

The reference track used in this categorisation is the "long welded rail with concrete sleepers", with 1 or 2 tracks and track width <15m. Correction terms relative to the reference track are proposed for each subcategory presented below :

Categories	Subcategories
Type of tracks	• Reference: (long welded rail with concrete sleepers) • Long welded rail with wood sleepers • Short rail with concrete sleepers • Short rail with wood sleepers
Number of tracks and platforms width	• Reference: (1 or 2 tracks, track width<15m) • 7 subcategories for 3<number of tracks<22 and 15m<track width<110m

Specific zones	• Switch gears • Steel bridges
Type of platform for tramways	• Concrete • Specific asphalt • Damped rail

2.2 Germany

In the German calculation scheme for railway noise (Schall 03), the following five categories have been established:

- Freight trains (velocity <100 km/h)
- Streetcars and underground trains (velocity < 80 km/h)
- Local trains (D, RB, RE) (velocity < 120 km/h)
- Long-distance trains (IC, EC, IR) (velocity < 200 km/h)
- High-velocity trains (ICE-family) (velocity < 300 km/h)

Correction terms exist for the application of wheel absorbers, streetcars and underground trains. The effect of brake type is included in the calculation.

Concerning tracks, the following categories have been defined:

- Streetcar track (with lawn)
- Ballast track with wooden sleeper
- Ballast track with concrete sleeper
- Slab track

Corrections are used for bridges, level-crossings and curves.

2.3 The Netherlands

In the Netherlands, the following categorisation has been devised for the national prediction scheme (SRM 2002).

For trains, 9 categories are distinguished. These are based on statistical emission measurements from the 1980s and 1990s. They correspond mainly to the type of braking system and traction and/or aerodynamic noise characteristics. New train types can be assigned to an existing category by measurement.

- Category 1: cast iron block-braked passenger rolling stock also including locomotives
- Category 2: combined disc and block-braked passenger rolling stock, as well as disc-braked passenger rolling stock and locomotives with additional block brake.
- Category 3: disc-braked passenger rolling stock with some electric traction noise
- Category 4: freight rolling stock, all freight wagons with cast-iron block brakes
- Category 5: cast iron block-braked DMUs, diesel electric passenger trains with only (cast iron) block-brakes and corresponding locomotives, as well as diesel electric locomotives.
- Category 6: disc-braked DMUs with traction noise
- Category 7: disc-braked metro and tram units
- Category 8: disc-braked electric intercity and regional trains, EMUs and corresponding locomotives, also those with added sinter or ABEX block brake.
- Category 9: high-speed passenger rolling stock mostly disc-braked with added block brakes on driven coaches, including TGV-PBA and Thalys.

All of these categories are illustrated in the following Figure 1 . For each category the typical number of coaches per train is indicated in brackets. Cumulative traffic noise emission calculation is made by counting the number of units of each category per day for each speed.
Emission levels are given in the form a + b lg V in octave bands. For the same categories, emission data are given for braking noise.
For tracks, the following classification is made, and a correction factor is given for each track type.

1. ballasted track on concrete monoblock or biblock sleepers
2. ballasted track on wooden or zigzag sleepers
3. ballasted track without continuously welded rails or interrupted by at most two jointed points within 50m
4. track with block base
5. track with block base and ballast
6. track with adjustable rail fasteners
7. track with adjustable rail fasteners and ballast
8. track with embedded rail
9. track on level crossing.

Corrections are also given for various types of bridge structures.

5 source heights are used in the centre plane of the track, to be able to predict the effect of noise barriers. These heights are 0m, 0,5m, 2m, 4m and 5m above the rail surface. This covers the radiation from the track and the wheels (rolling noise), traction noise at various heights such as bogies, fan louvers and exhaust on the roof, and aerodynamic noise at bogies, roof recess (4m) and pantograph (5m).

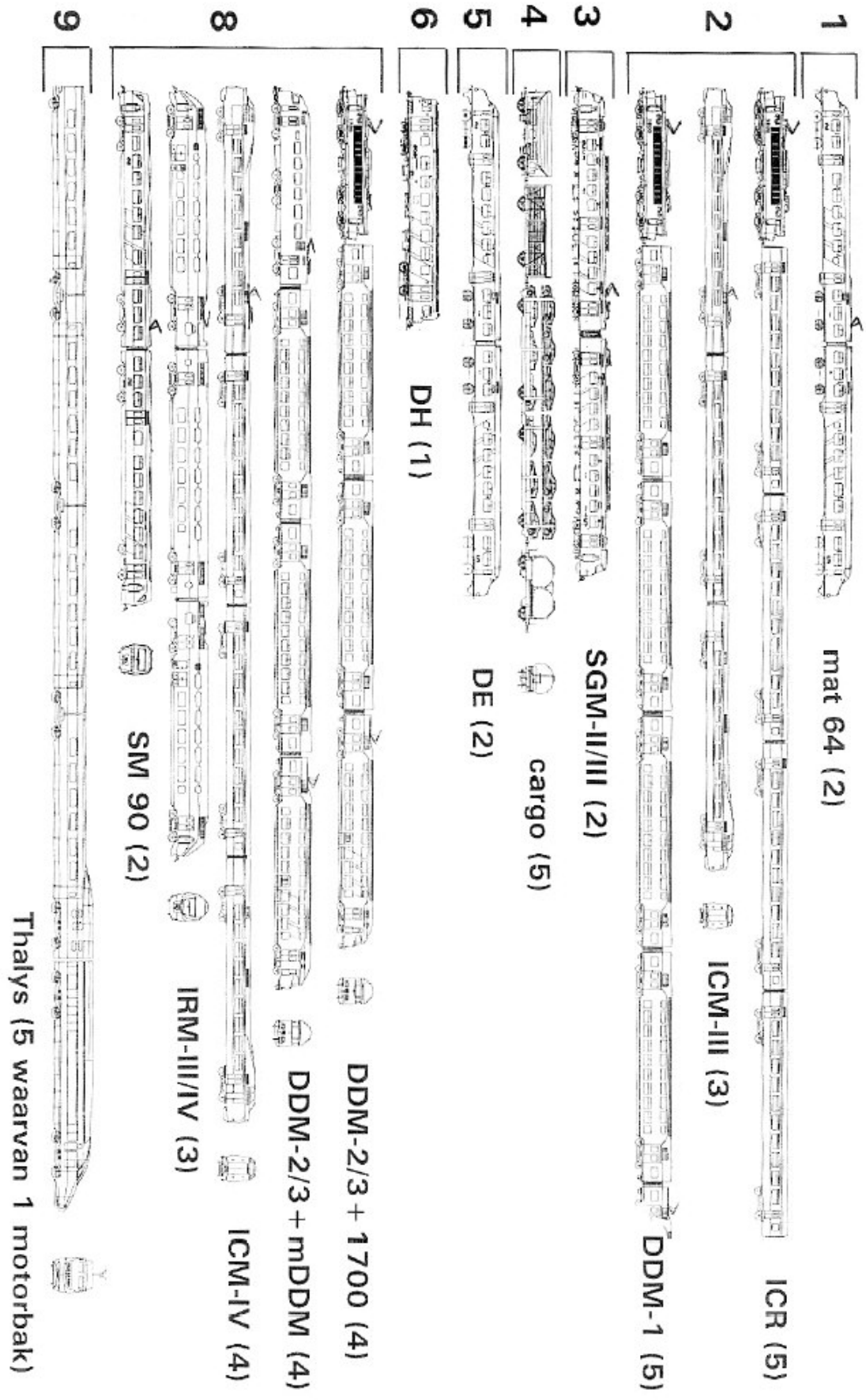


Figure 1: Overview of categories of the Dutch railway noise calculation scheme

2.4 Norway

Classification work was done for implementation into the Nord1996 model and more recently into the Nord2000 model.

Nord1996.
The following categories are used in the present prediction method:

Train name	Type	Traction type	Speed interval, km/h	Speed interval, verified by measurements, km/h	Correction for better than normal wheel rail maintenance, dB
GODS	Old goods trains	El	30-110	40-100	-2
BM69	Suburban	El	30-150	40-140	-2
BM70	Intercity	El	90-130	100-120	-2
PASS	Long dist. pass. train	El	50-130	60-120	-2
BM65/68	Old suburban	El	50-110	60-100	-2
BM71	GMB high speed	El	30-200	120-200	-3
BM72	New Suburban	El	30-200	Spec.	-3
BM73	New long dist. pass. Train. "Signatur"	El	30-200	Spec.	-3
BM93	Intercity. Talbot Talent. "Agenda"	Diesel	30-200	Spec.	0
PASS-ny	Long dist. pass. El.18+B7 or similar	El	30-200		-4
Gods-ny	Goods trains with low noise brakes	El	30-200		-3
Gods-Di8	Goods train with Di8 locomotive	Diesel	30-200		-4
Gods-di	Undefined diesel powered goods trains	Diesel	30-200		-2
Pass-di	Undefined diesel powered pass. trains	Diesel	30-200		-3

The first 6 train types were the most usual around 1995, and they were well documented by measurements for Nord1996. For the other trains, mostly newer, the source data are based on their similarity with the older train (e.g. BM73 is very similar to BM71) or on delivery

specifications ("Spec" in the table, for further details, see [2]). A large amount of supplementary measurements have been done since 1995, but the results have not yet been summarised for inclusion in the method. The source data are valid for continuously welded rails.
Nord1996 give general corrections for wheel/rail maintenance, this has been further developed into type related correction for the Norwegian trains, as shown above. Further more, the method gives corrections for jointed rails, switches and crossings, and bridges with and without ballast.

Nord2000
The Nord1996 source data have been modified for use in Nord2000. No new measurement results have been included. In Nord2000, the trains are divided in 5 main categories, each with sub-categories different from country to country. In Norway the train categories are:

Main category	Sub category	Category name
1		**High speed trains (≥ 180 km/h)**
	1a	Gardermoen train, type 71
	1b	Express Passenger train, type BM 73
2		**Normal speed Inter-City/Express trains**
	2a	Type BM 70 (Passenger train set)
	2b	Electric (El 18, locomotive driven, in limited use)
	2c	N-Pass (El-locomotive driven)
	2d	Diesel (Di8, locomotive driven)
3		**Passenger train sets**
	3a	Type BM 69 (local)
	3b	Type BM 92 (local)
	3c	Type BM 72 (local)
	3d	Type BM 93
4		**Freight trains, locomotive driven**
	4a	N-goods (El 16)
	4b	Electric (El 18, in limited use)
	4c	Diesel (Di8)
5		**Others**

2.5 Sweden

Nord1996
The situation in Sweden, Finland and Denmark is similar to that of Norway. A large number of measurements were carried out for Nord 1996. The Finnish and Swedish data also includes categories for rails on wooden sleepers. Categories and speed intervals are available for each country, and can be provided if necessary.

Nord 2000
In Nord2000, the trains are divided in 5 main categories, each with sub-categories. The railway tracks are divided as 4 categories. Driving conditions are also divided into 4 categories.

2.5.1 Train categories

The following train categories for Swedish trains are defined in the Nord2000 model.

Main Category	Sub category	Category name
1		**High speed trains (≥ 180 km/h)**
	1a	X2000
	1b	Arlanda train
	1c	Öresund train (Sweden and Denmark)
2		**Normal speed Inter-City trains**
	2a	With RC engine
	2b	
3		**Local and regional trains**
	3a	X10, X12 (el)
	3b	Y1 (diesel)
	3c	Y2 (diesel)
4		**Freight trains**
	4a	Normal, RC engine (el)
	4b	Normal, T44 engine (diesel + el)
	4c	Iron ore train (Sweden and Norway)
5		**Others**

2.5.2 Track categories

The following railway track categories are defined in the Nord2000 model.

Main category	Sub category	Name
1		**Modern** (ballasted, concrete sleeper, welded joints with UIC 60 rail , soft pads)
	1a	Well maintained (roughness < X)
	1b	Average (X ≤ roughness ≤ Y)
	1c	Worse than average (roughness > Y)
2		**Semi-modern** (ballasted, concrete sleeper, welded joints with UIC xx rail, soft pads)
	2a	Well maintained (roughness < X)
	2b	Average (X ≤ roughness ≤ Y)
	2c	Worse than average (roughness > Y)
3		**Old** (ballasted, wood sleepers, non-welded joints with UIC xx rails)
	3a	Well maintained (roughness < X)
	3b	Average (X ≤ roughness ≤ Y)
	3c	Worse than average (roughness > Y)
4		**Track on steel bridge**
	4a	Well maintained (roughness < X)
	4b	Average (X ≤ roughness ≤ Y)
	4c	Worse than average (roughness > Y)

2.5.3 Driving conditions

The following driving conditions are defined in the Nord2000 model.

Category	Name	Objective description
1	Cruising	Constant speed
2	Acceleration	Continuous acceleration[1)]
3	Deceleration	Continuous deceleration[2)]
4	Bends	Squeals

[1)] E.g. after stations or speed limit signs
[2)] E.g. before stations or speed limit signs

2.6 Noise creation limits for railways proposals for the TSI (Technical Standard for Interoperability)

Eurailnoise [3] and the UIC report [4] on noise creation limits for railways dealt with the proposition of noise creation limits for the standards of interoperability. Categorisations procedures have not been proposed within these studies but the types of trains considered can be mentioned for our purpose.

- In Eurailnoise, noise limits are proposed for the following types of trains :

Conventional railway system	Locomotives
	Conventional multiple units and railcars
	Passenger coaches
	Freight wagons
High speed trains	
Light rail transit	Tram, metro

- In the UIC report, an updated overview of noise creation is given for the following types: freight, DMU/EMU, locomotives, passenger coaches and high-speed trains. It also takes into account the different brake system types: disk, cast iron, K composite blocks and sintered. In the last part of the report, noise limits values are proposed for:

Classical speed	Diesel locomotives
	Electrical locomotives
	EMU
	DMU
	Passenger coaches
	Freight wagons
High speed trains	

2.7 STAIRRS vehicle classification descriptor

In the STAIRRS project, a descriptor was formulated for rail vehicles that includes the main relevant parameters for noise. The following paragraph is derived from the STAIRRS report on this subject [5]. It can be used to describe a vehicle in a database. For Harmonoise, one possibility is to use this kind of descriptor to estimate the noise emission for a particular vehicle type if all relevant parameters are known. A major benefit of this is that all existing national categories can be mapped according to a common "international system".

2.7.1 Background

The number of axles per metre train length and the braking type are the two most distinctive "vehicle-dependent" features with regard to noise creation. In addition, features such as vehicle type, load and wheel diameter have a significant influence on noise creation as well as the type of power unit. For the comparison of the noise created by different vehicles (passenger or freight) as measured in different countries, it can make sense to categorise the vehicles according to such features, thus avoiding different names for (acoustically) similar vehicles, e.g. Corail (SNCF) and ICR (NS).

2.7.2 The STAIRRS label format

A vehicle is not categorised by names such as "intercity train" or "freight wagon", but by a label of 7 digits that represent acoustical relevant parameters. The label for a disc-braked intercity train (pulled by a loco) will read **P4lpuln**, while the loco may be **L4meulc**.

digit:	1	2	3	4	5	6	7
descriptor	**train type**	**number of axles per vehicle**	**length of vehicle**	**vehicle type**	**load**	**wheel diameter**	**brake type**
how it is encoded	type of the train	the actual number of axles	the class of length between the buffers	a letter that describes the type	freight vehicle load	the class of diameter	a letter that describes the brake type
codes allowed	**O** Other (i.e. maintenance vehicles...)	**u** unknown	**u** unknown	**u** unknown	**u** unknown	**u** unknown	**u** unknown
	H High speed passenger	1	**l** long, >20m	**m** Self-motored passenger coaches	**l** loaded freight	**l** large, >800 mm	**c** cast-iron
	P conventional Passenger	2	**m** medium, 12 to 20 m	**p** pulled passenger coaches	**n** not loaded freight	**m** medium, 500 to 800 mm	**k** k-block
	F Freight	3	**s** short <12 m	**d** diesel loco		**s** small < 500 mm	**n** non tread braked, like disc, drum, magnetic
	L Loco	4		**e** electric loco			
		et cetera		**E, F, G, H, I, K, L, O, R, S, T, U, Z** UIC-designation for freight vehicles see Figure 3			

Appending

The format allows for appending digits – only the first 7 digits are obligatory. However, an index should be appended in case of separate vehicles groups with the same 7-digit label in one train. For example, if a train consists of 3 different groups of vehicles, of which the 2 outer groups are equal, but differ from the middle one:

first group: **`P4lpuln_1`**.

second group: **`P4lpulc`**

third group: **`P4lpuln_2`**

⇒ *In the STAIRRS Excel form, this label is assigned to the "Vehicle / group or vehicles identity" field.*

Remarks on digits 2 an 3:

It is important that all database contributors have the same feeling of what one "vehicle" actually is, as there are types of vehicle sets that remain coupled during their lifetime:

- many passenger trains consist of 2 or more vehicles that are never disconnected. These should be regarded within the context of the STAIRRS database as one vehicle. An example of a 3-vehicle passenger train "Talent OME" is shown on the left of Figure 2 (this is a self-motored passenger train).
- some freight vehicle sets consist of 2 (or more) vehicles that have one UIC designation. An example "Hirrs4" is shown on the right of Figure 2. As it is not always clear during way-side data collection whether a vehicle is part of a set or not, it is proposed to consider them as separate vehicles in the database coding: **`F2mHulu`**.

Figure 2: Examples of vehicles with special axle/unit ratio

- In cases of coupled vehicles, the number of axles can also be odd: e.g. if a common 2-axle bogie is shared by two coupled vehicles, the number of axles per vehicle is 3.
- Some passenger trains, like the above Talent OME, have a fractional number of axles per coach if the train is treated as a whole. This train has 8 axles on 3 vehicles. In this case, case the number should be rounded to the nearest whole number, i.e 8/3= 2.7 ≈ 3 axles per coach.

Remarks on digit 4
Freight trains may take many shapes. The first letter of the UIC designation is used for freight. The drawings on Figure 3 may help.
In case of multiple unit passenger trains with motored and non-motored vehicles, use **m** if the train is analysed and contributed as a whole. In case the non-motored vehicles can be cut separately, use **p** for these and **m** for the motored ones. For instance, in the above example of the 3-vehicle Talent OME, the outer vehicles are named **p3mmumn**, so the whole train is named **p3mmumn** as well.

Remarks on digit 5
Container wagons are regarded as loaded, if there is at least one container present. Even though a container may be empty, digit 5 is set to **l**. This makes it possible to sort on empty flat wagons.
In many cases it is not clear if a vehicle carries significant load: use **u**. Also use **u** for passenger coaches.

Remarks on digit 6
The wheel diameter for most passenger and freight trains is usually 920 mm (=**l** for "large"). Some flat container carriers and car carriers have smaller wheels. For passenger trains, some "light rail" vehicles may have smaller wheels.

Remarks on digit 7
The brake type is usually not clear from watching the trains passing by. Braking blocks, if visible, can be cast-iron, k-blocks, sinter et cetera. Only by using a priori knowledge of the rolling stock can the braking type be identified. In case of combinations of braking type, the type that can be expected to affect the wheel tread most is decisive (**c** or **k**).

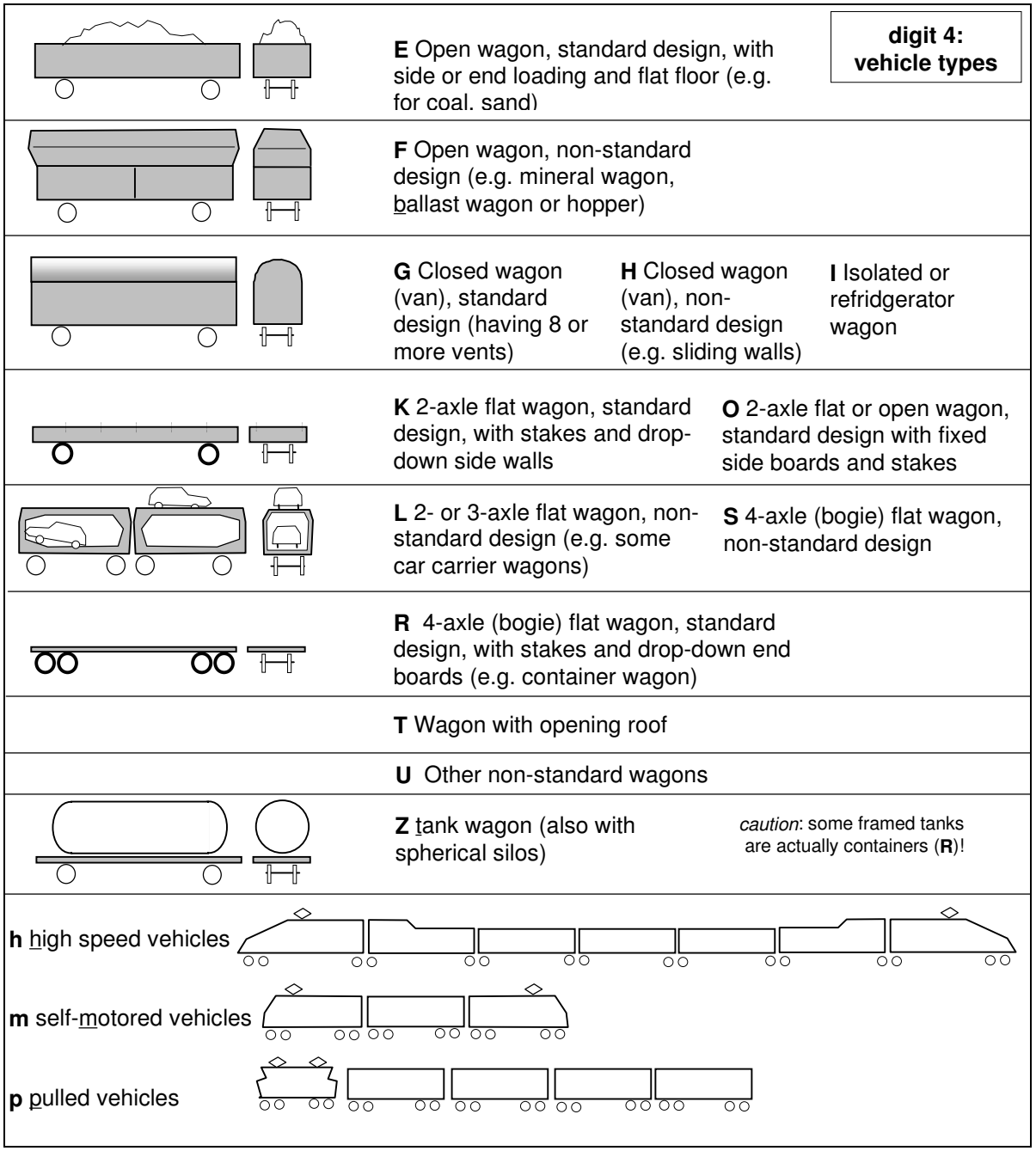


Figure 3: Code for the vehicle type (digit 4)

Final remark

It is not possible to provide a guideline for labelling which is unambiguous and practical at once. In cases of doubt, keep the purposes of the database in mind. Round off to descriptors belonging to the acoustically worst case.

2.8 A possible track descriptor

Although STAIRRS did not produce a track descriptor, this can be proposed fairly easily in analogy to the vehicle descriptor, as shown below.

digit:	1	2	3	4	5	6	7	8	9	10	11
descriptor	**Track type**	**Track base**	**Sleeper type**	**Rail Fastener**	**Track dynamic characte ristics**	**Rail type**	**Sleeper spacing**	**Additional measures**	**Roughness condition**	**Rail joints**	**Curvature**
how it is encoded	Application speed related	Type of track base	Sleeper type indicator	Fastener abbreviation	Decay rates	kg/ m	Distance in cm	A letter describing acoustic device	Indicator for roughness	Presence of joints and spacing	
codes allowed	**H** High speed (>200 km/h)	**B** Ballast	**W** Wood	**S** Springclip				**D** Rail damper	**E** Well maintained and very smooth	**N** None	
	M Medium speeds	**S** Slab track	**M** Concrete mono-block	**D** Delta plate				**B** Low barrier	**M** Normally maintained	**S** Single switch	
	L Only low speeds below 100 km/h	**C** Concrete bridge	**B** Concrete bi-block	**B** Bolted plate				**O** Other	**N** Not well maintained	**D** Two switches per 100 m	
		E Steel bridge	**Z** Steel zigzag	**O** Other					**B** Not maintained and bad condition	**M** More than two switches per 100 meter	
		O Other	**S** Steel								

The noise radiated by the track is strongly related to the composition of the track (e.g. rail and sleeper type, stiffness and damping of the rail fastening and of the ballast). For digit 2, the physical parameters that are important are the dynamic stiffness and damping of the base; for digit 3, it is the mass and the geometrical characteristics of the sleeper, for digit 4, the pad dynamic stiffness and damping. As regards digit 5, it has been shown that the track decay rate is the most appropriate parameter to describe the track vibration response. It includes implicitly the uncoupling frequency between rail and sleeper. Dynamic stiffness and damping of the base and the pad can be deduced from the knowledge of the track decay rate. It can furthermore be directly measured [6]. Different templates could be proposed as default.

⇒ *This table of descriptors is a proposal that will be further discussed in connection with results of other tasks of the WP1.2 (source knowledge and measurement methods).*

2.9 Synthesis

Existing national categorisations are mostly based on "type names" for the trains in each country, considering their use, their length, and sometimes, their braking system type.
Concerning the tracks, the type of track construction is often used to describe the categories e.g. type of rail, sleepers, ballast, etc, and the categories can be fairly similar from one country to another.
To create internationally valid categories, it appears necessary to use physical parameters that are directly relevant to the noise creation. Preliminary ideas for this type of categorisation are given in next paragraph.

3 Summary

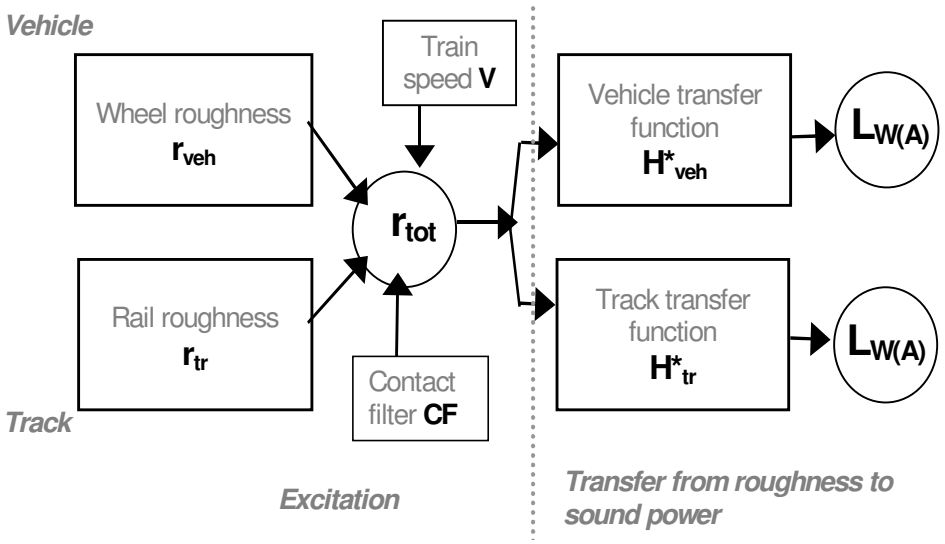
A proposal for categorisation is suggested here which on the one hand should be practical and on the other should be acceptable for prediction purposes. Therefore it does not yet include all relevant parameters but some predominant ones which can be measured. A categorisation proposal must be compatible with existing national categorisation systems, although these are often based on braking systems or other design features.

3.1 Parameters

The relevant acoustic parameters cannot always be derived accurately from basic design features such as the wheel diameter. For each type of source, a minimum of parameters will be required to be able to make some kind of prediction. Although for rolling noise a vehicle and a track descriptor can be given, for traction noise and aerodynamic noise this has not yet been done. So, a basic proposal is made here.

3.1.1 Rolling noise

Rolling noise can be characterised by the following scheme.



In the STAIRRS project some tools are developed to measure separated roughness levels and transfer functions.
The dependency on train speed is around 30 lg V (in A-weighted level), although the spectral dependency must be described by the speed dependency of the roughness spectrum (in the frequency domain) or a simplification of this.

Track categorisation

- Rail roughness

  Categorisation of rail roughness is difficult, because there seems to be little correlation depending on the track type or operation. Therefore it may seem impossible to find roughness descriptors based on construction parameters.

  However with existing measurement tools it might be possible to make a distinction between corrugated rail, average roughness and specially monitored track.

- Track transfer function
  The track transfer function will be dependent on some of the parameters that are described in paragraph 2.8 (except the roughness condition.)
  In some cases, additions to the sound power level could be made e.g. for impact noise due to rail joints.

Vehicle categorisation

- Wheel roughness
  It has been shown that wheel roughness is strongly dependent on the type of braking system. It is therefore relevant to use this "vehicle factor" as one of the important categorisation parameters. However, there is little insight into the average roughness levels for each brake type. A proposal based on existing, relative noise levels for vehicles with different braking systems should be made.
- Vehicle Transfer Function
  A first study of the results from STAIRRS seems to indicate that one of the main parameters is the wheel diameter. Others are the number of axles and vehicle length, wheel damping and shielding. In addition to the STAIRRS vehicle classification descriptor, for a calculation scheme a descriptor for Additional Measures (**n** none, **w** wheel dampers, **b** bogie screens, **u** unknown) can be useful. The number of axles and vehicle length are important for the quantity used for the sound emission (sound power per axle, per vehicle or per vehicle length.). For the special purpose of calculating the vehicle transfer function with TWINS, the knowledge of the dynamic modal properties of the wheel will be necessary. [7]

Contact filter

The contact filter should be determined from

- The load
- The wheel diameter
- The curvature of the rail head

3.1.2 Traction noise (locos and powered vehicles)

For traction noise generally the following design features are important:

- Traction system type: Internal combustion engine/Electric drive/Other
- Number of traction units (motors)
- Rpm of the traction unit, load and acceleration
- Sound pressure or power spectrum at given drive rpm, due to drive only
- Sound pressure or power spectrum at given fan rpm, due to fan only
- Number of fans
- Rpm of the fans

Although design features such as engine enclosure and exhaust/intake performance are also important, here they are assumed a fixed factor for a specific vehicle.
A particular issue for traction noise is that the dependency on rpm of the drive unit or the fans is more important than the train speed. For this reason the traction noise level will tend to vary between 0 to 20 lg V, depending on the presence of drive noise or fan noise and on the individual design and operating conditions.
Fan noise tends to have a 50 lg rpm dependency, whilst drive noise often has a 30 lg rpm dependency.

Fan noise is also dependent on efficiency and diameter (design factors) and may also be temperature dependent. Drive noise may also be somewhat load dependent.
These effects are not yet included here.

A first proposal for traction noise specification consists of four quantities:
- A nominal idling fan rpm n_{f0}
- the sound pressure spectrum of a stationary vehicle at 7,5m at this rpm, $L_{pfan,nf0}$
- A drive rpm at which traction noise is predominant, n_{d0}
- the sound pressure spectrum of a stationary or moving vehicle at 7,5m at this rpm, $L_{pdrive,nd0}$.

3.1.3 Aerodynamic noise

For aerodynamic noise the following design properties are important:
Characteristic design of the bogie combined with the front shape, pantograph and recess and of other protrusions. For practical reasons however, these can be combined into a single qualifier, namely the known pass-by sound pressure or sound power spectrum due to aerodynamic noise at a given train speed. To obtain noise levels at other speeds this is then corrected by 60 lg V over the whole frequency range.
A first proposal for aerodynamic noise specification consists of two quantities:
- For a given 1/3 octave band, the speed at which aerodynamic noise exceeds rolling noise by 5 dB(A) or more, $V_{aero,0}$
- the sound pressure spectrum in 1/3 octave bands at 25m for this speed, $L_{peq,Vaero,0}$.

3.2 Trains & tracks categorisation

The following table gives possible descriptors suitable for categorisation, for a given country. Existing national categories can be converted into the general descriptors in the middle column. If additional data is available this can also be provided.

Vehicle type or for a given country, train type	**Descriptors (see §2.7 & 2.8)**	**Additional data if available (more complete data from measurements)**
Freight wagons or passenger coaches without engines	Vehicle descriptor Track descriptor	Vehicle transfer function Track transfer function Total effective roughness, Or wheel and rail effective roughness
Diesel locomotive, DMU, Electric locomotive or EMU	Vehicle descriptor Track descriptor	Vehicle transfer function Track transfer function Total effective roughness, or wheel and rail effective roughness
	Lpeq(7,5m) for fans at rpm,n_{f0} Lpeq(7,5m) for drive at rpm,n_{d0}	Full spectrum collection or formula describing Lpeq(rpm,V,…) behaviour

High speed train sets	Vehicle descriptor Track descriptor	Vehicle transfer function Track transfer function Total effective roughness, or wheel and rail effective roughness
	Lpeq(7,5m) for fans at rpm,n_{f0} Lpeq(7,5m) for drive at rpm,n_{d0}	Full spectrum collection or formula describing Lpeq(rpm,V,…) behaviour
	Lpeq(25m) for train speed where aerodynamic noise dominates, $V_{aero,0}$	Full spectrum collection or formula describing Lpeq(rpm,V,…) behaviour

This first proposal of categorisation needs to be further worked on to be part of the Harmonoise railway noise source database. Questions still have to be solved such as:

- What is the accuracy that we need for propagation purpose and what is the relationship with details specified in the proposed railway source model
- for rolling noise: how to propose default value of roughness and transfer function? How to get practical measurement methods for them? Which details from the vehicle and track descriptors are acoustically relevant and what can be left out? How to obtain default sound power levels from the descriptors?

4 Conclusion

In this document, the categorisation issue for railway vehicles has been reviewed. The following was concluded:

- The categorisation system used today in several European countries is mainly based on train types and track designs with a more or less accurate link with acoustic properties (mainly braking system for vehicles). This type of categorisation has several shortcomings for the use in a common European prediction method.
- Existing categories for train types sometimes mix different vehicle types, especially for freight or passenger trains with locomotives, where the noise characteristics of the locomotive and the individual wagons can differ significantly. At a national level this may not necessarily be an issue, but to obtain the full benefits of low noise vehicles a harmonised approach is required to deal with this.
- The most advanced vehicle categorisation has been put forward in the STAIRRS project. It proposed vehicle descriptors that include the main relevant parameters for rolling noise and that could be used to map national categories on this "international" classification. A similar approach for track properties has been indicated in this report. These categories may be a good start for the Harmonoise purposes but they need to be adapted and simplified: the descriptors that have major noise effects should be identified first and those that are less critical can be ignored.
- No general categorisation exists for traction or aerodynamic noise. A first summary was also put forward in this report.

A proposal has been started here from a review of the main source parameters:

- For rolling noise, roughness and transfer function (both for vehicle and tracks) can be considered as basic parameters in the model. The method to obtain these parameters

practically should be further discussed as well as the link with their detailed descriptor. This should be done in other tasks of the WP1.2 (source knowledge and measurement methods tasks).

- Traction noise and aerodynamic noise can only be described with very basic parameters. This point will be further discussed in other task of WP1.2 but no detailed studies will be carried out for these sources. The modelling will stay very basic compared to the rolling noise model.
- The question of train categorisation from the source model should be keep in mind without forgetting that a statistical approach is needed to characterise a given traffic flow. For example, for wheel roughness, considering a train wheel by wheel is unnecessary.

This proposal needs further development to be useful for the formulation of the railway source database and may be considered as a guideline for further work in WP1.2.

5 References

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