CNOSSOS-EU Railway noise versus The EU Interim Railway noise Standard Calculation Method II

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Union Internationale des Chemins de Fer Vienna

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Contents

dGm[R]

The developments last 17 years

Harmonoise	1999 – 2004	Extensive research to come to an engineering method. Methods for calculations in a large number of meteo classes
Imagine	2004 - 2007	Further research on databases, aircraft noise and industrial noise
Good Practice Guide part 1	2004	Guidelines for doing calculations
Good Practice Guide part 2	2006	More extensive guidelines
CNOSSOS-EU	2008 – 2014	Harmonoise/Imagine was considered too extensive so it was desirable to establish a simpler method

The first objectives for Harmonoise in 1999 / 2000

The red and the green areas

Identification of ‘Hot Spots’

The first investigation

Inaccuracy up to 3-5 dB(A)

Distinction between a poor quality and an acceptable noise environment

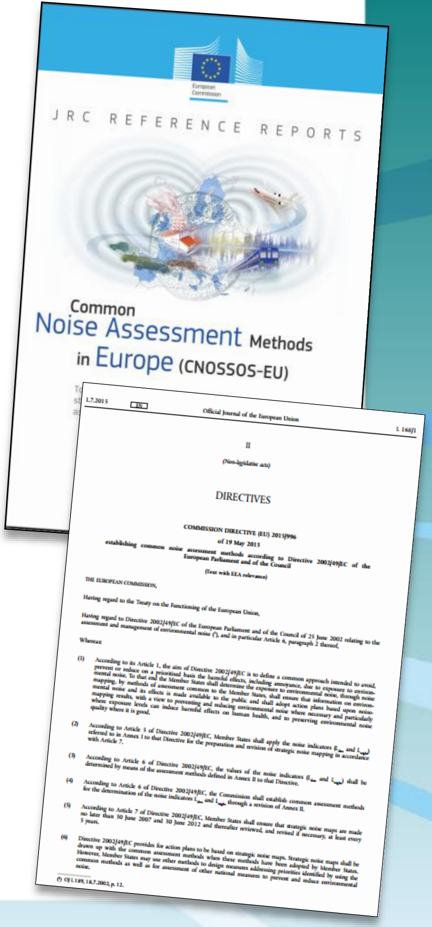
Further discussions to much higher accuracy

Common method for EU

DG JRC published the final report on CNOSSOS-EU in August 2012 with detailed technical descriptions of engineering methods for:

- Source models for roads, rail and industry
- Point to point propagation model based upon NMPB 2008
- Aircraft noise mapping to be undertaken using ECAC Doc 29 3rd Edition, 2005

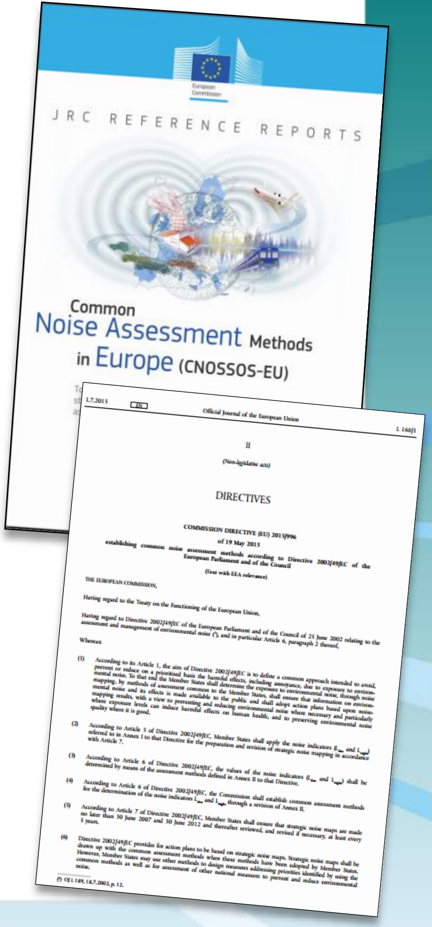
Directive of 19 May 2015 to have the CNOSSOS-EU method in Annex II of the END as the Common Method for use during round 4 of strategic noise mapping in 2022.



Common method for EU

CNOSSOS-EU should be designed to produce plausible noise maps showing plausible results.

For the purposes of CNOSSOS-EU, a parameter is considered essential if the range of values of the parameter can take yields variations in L_{den} or L_{night} of more than ±2.0 dB(A) 95% C.I.



Standard Calculation Method II

The Dutch calculation method version of 1996

Standard Calculation Method II is the EU Interim Railway for noise mapping

By the way: In the Netherlands there are newer versions of this calculation method

Fields of application

For large areas

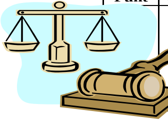
Noise mapping
(large scale)

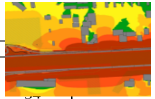
More
generalized data
(defaults)

For individual objects

Support to the EU level policy
Support MS policy aspects
Local action plan aspects
Assessment
Detailed noise maps

Minimum
requirements
for data





Punt	Geen maatr.	2 m	3 m	[illegible]
[illegible]	62	57	54	[illegible]
[illegible]	61	55	53	[illegible]
[illegible]	61	56	55	[illegible]
[illegible]	60	56	55	54
[illegible]	61	55	53	51
[illegible]	61	54	[illegible]	50
[illegible]	60	53	[illegible]	[illegible]

In common….

Defined in the frequency range from 63 Hz to 8 kHz

Calculations in octave bands

The A-weighted long term average sound level for day, evening and night is computed by summation over octave bands:

$$L_{Aeq,T} = 10 \times \lg \sum_{i=1} 10^{(L_{eq,T,i}+A_i)/10}$$

A_i denotes the A-weighting correction according to IEC 61672-1

i = frequency band index

T is the time period corresponding to day, evening or night

CNOSSOS-EU Railway noise
versus
Standard Calculation Method II

Noise Sources

Sources

SRM II

Physical source types:

1. rolling, impact and traction noise
2. aerodynamic noise
3. bridges

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Physical source types:

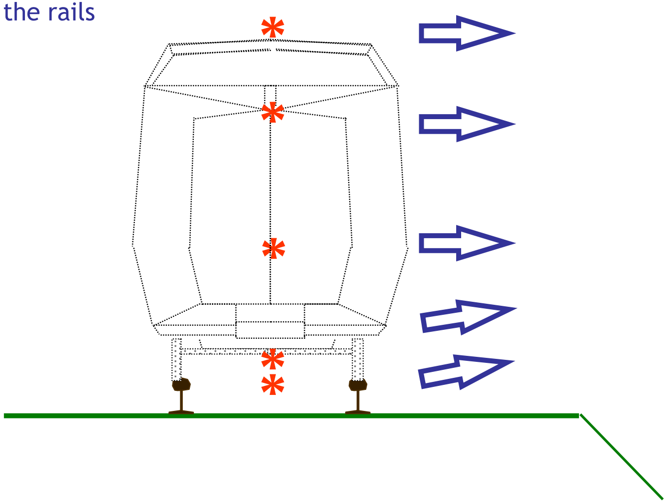
1. rolling and impact noise
2. curve squeal
3. traction noise
4. aerodynamic noise
5. additional effects (as bridges and shunting yards)

Source positions

SRM II

- Centre between the rails
- Source heights:
  above head of rail

⇨ 0.0 m
⇨ 0.5 m
⇨ 2.0 m
⇨ 4.0 m
⇨ 5.0 m



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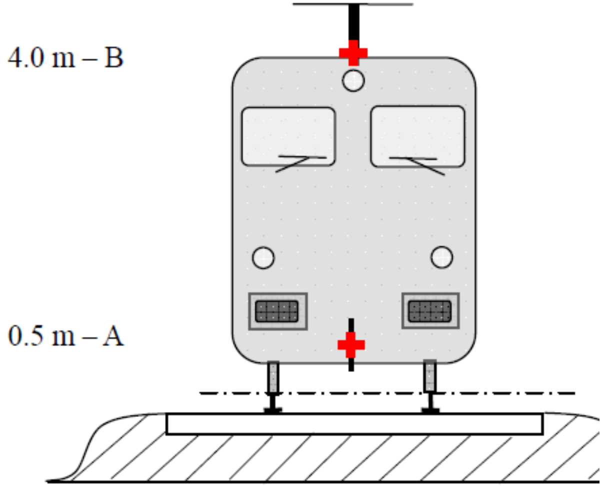
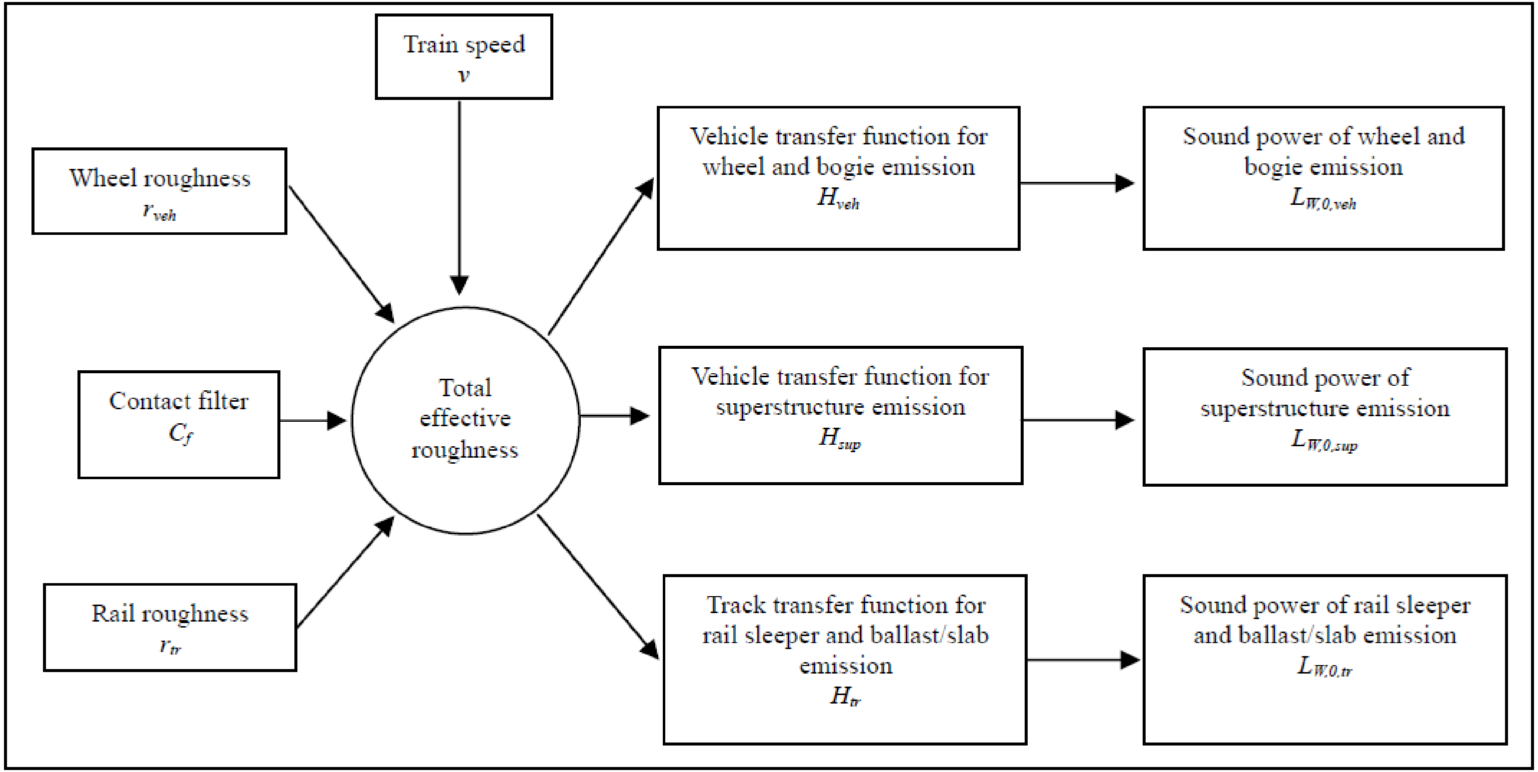
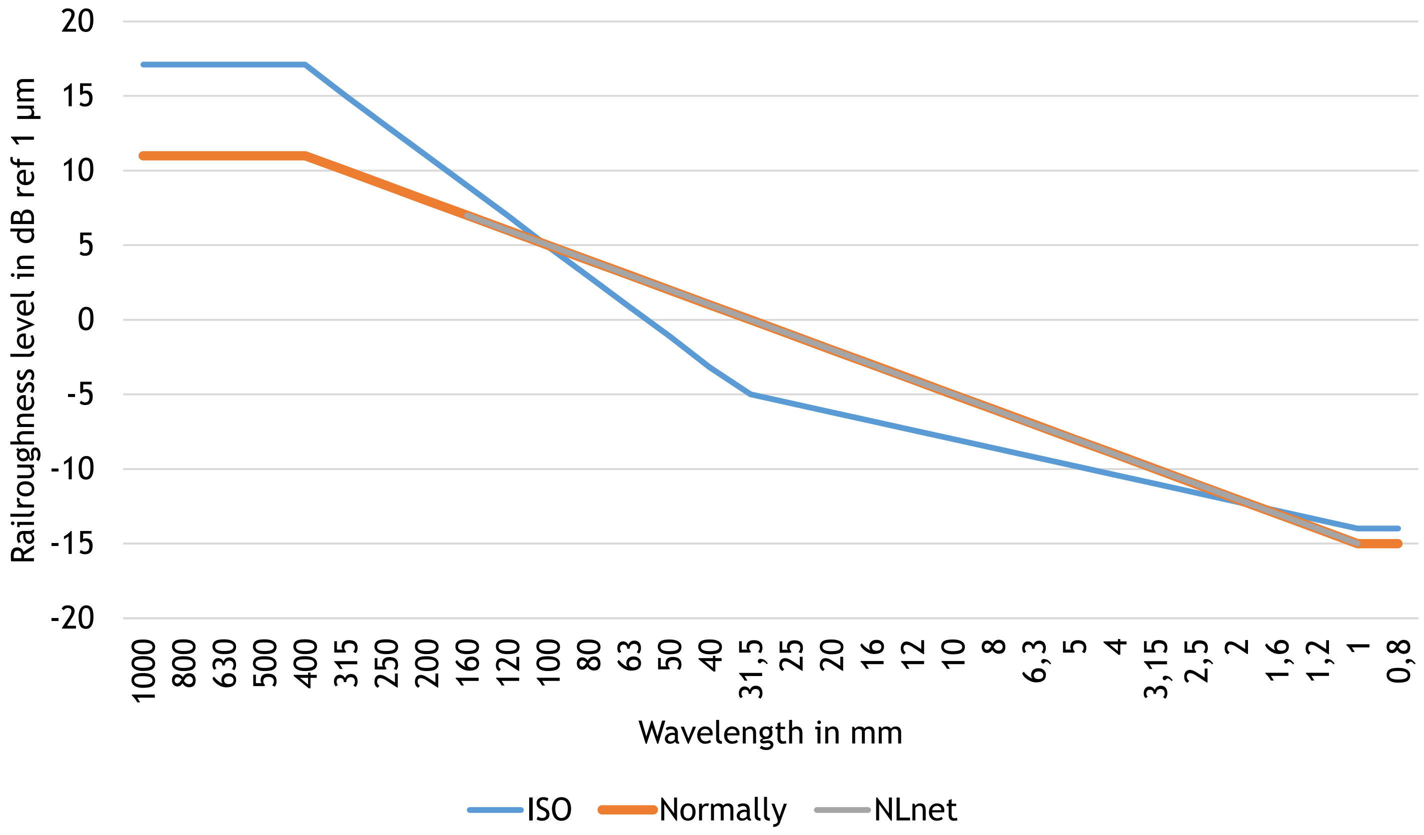


Mind that the source positions also have direct relations to barrier attenuations !

Scheme of the use of the different roughness and transfer function definitions



Rail roughness



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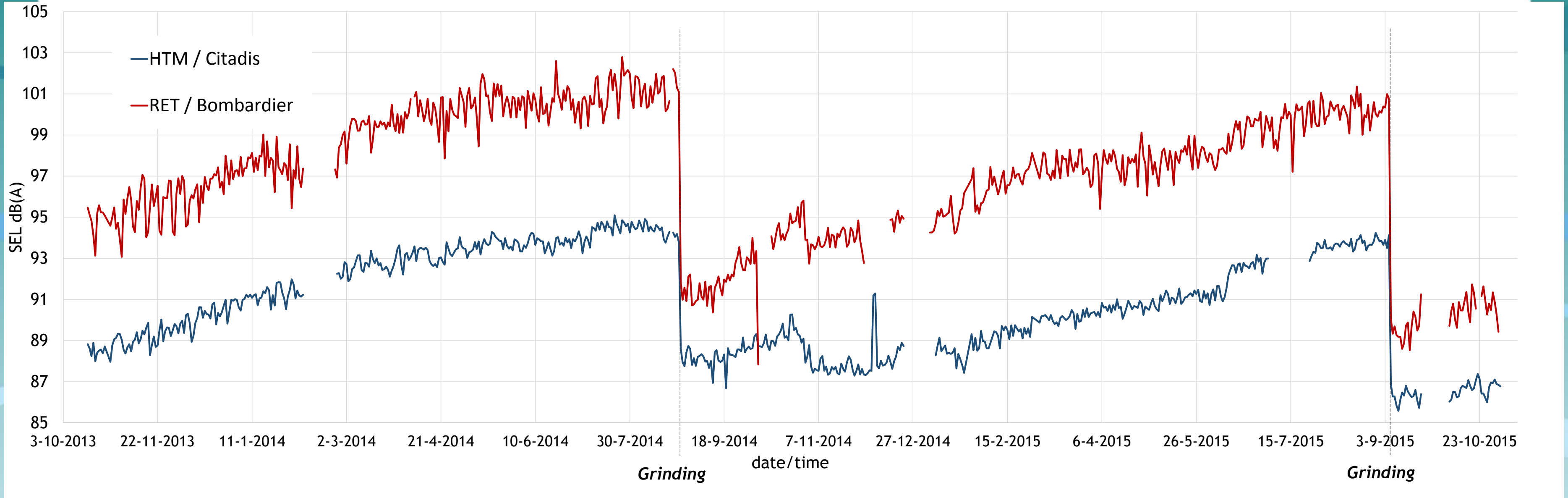
Results over several years of light-rail vehicles



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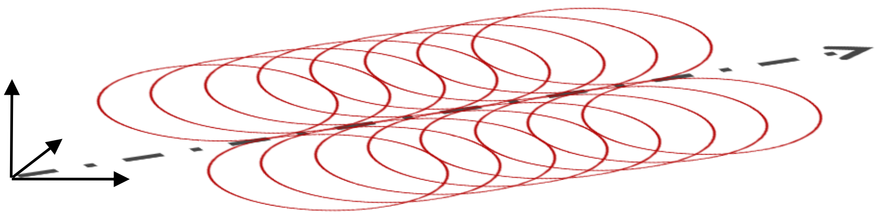
Directivity

SRM II



Dipole - COSIN function on the horizontal directivity

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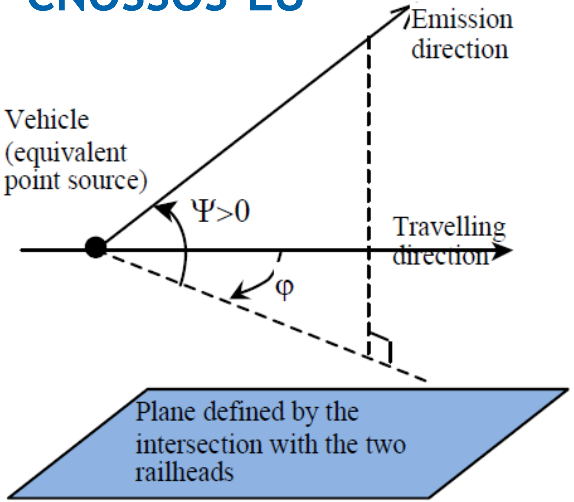
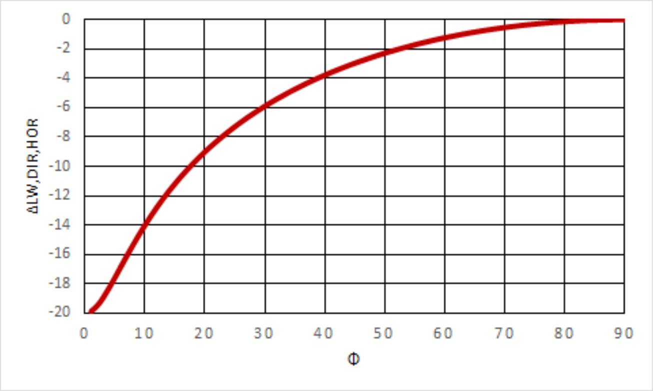


$\Delta L_{W,dir,vert}$ is the vertical directivity correction function of ψ

$\Delta L_{W,dir,hor}$ is the horizontal directivity correction function of φ

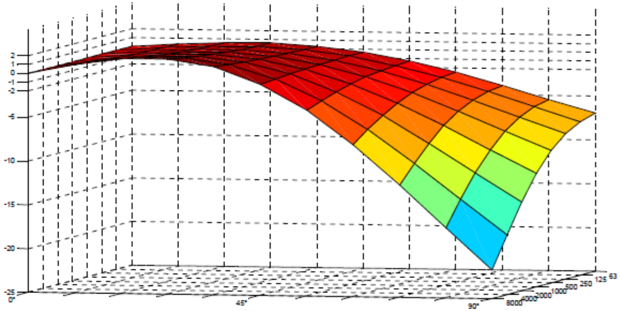
Directivity - default

Horizontal low and high source

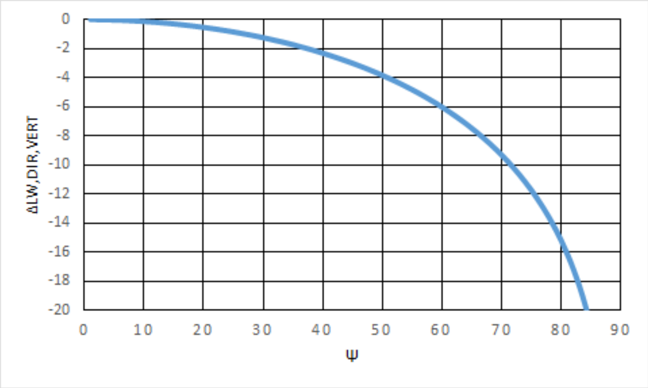


Dipole - SIN function on the horizontal directivity

Vertical low source - aerodynamic



Vertical high source - aerodynamic



Curve squeal noise

Adding to the rolling noise sound power spectra

- for at least a 50 m length of track
- for all frequencies

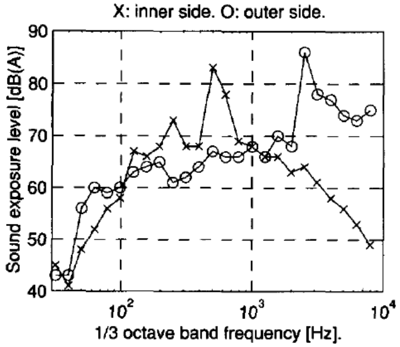


Figure 1.3: Curve squealing: spectrum of the sound exposure level. Single measurements made by van Leeuwen [64]

- 8 dB for R < 300 m
- 5 dB for 300 m < R < 500 m

Squeal noise is associated with the sources at 0,5 m (source A).

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Input data aspects

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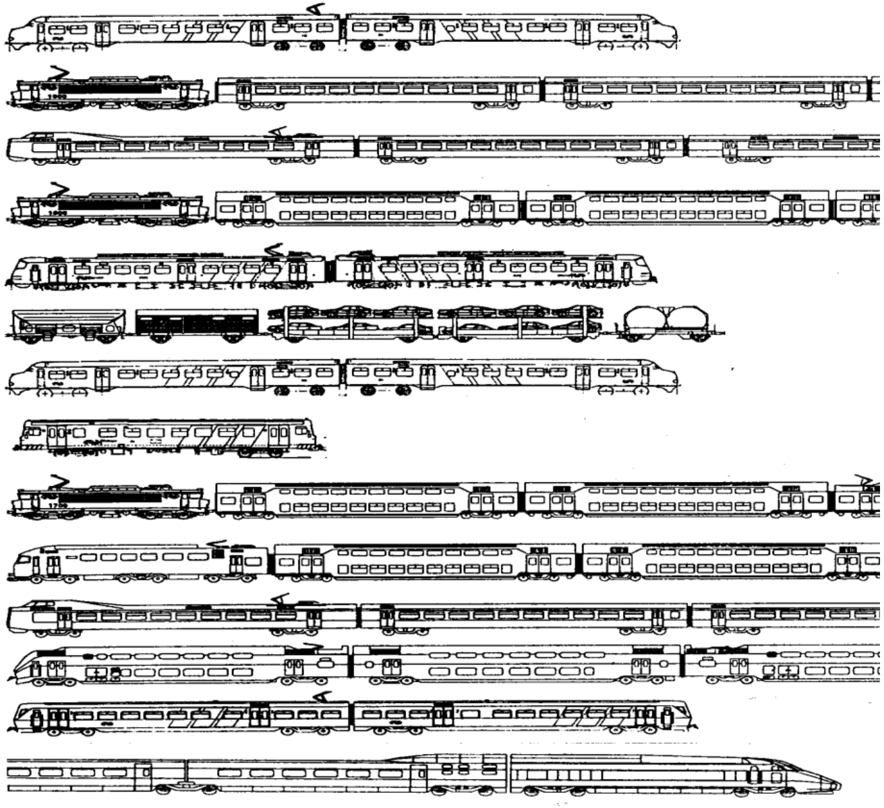
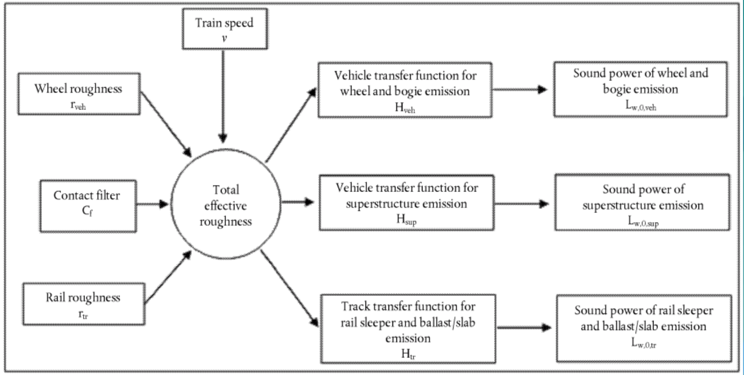
SRM 2 - Predefined Train Categories



The CNOSSOS-EU Rail source model

Complex source model depending on

- rolling noise (rail/wheel roughness)
- impact noise (crossings/switches/junctions)
- squeal (radius)
- traction noise
- aerodynamic noise
- directivity
- bridges etc.



The source model is in 1/3 octave, however for propagation and octaves are used

2 source heights at 0.5 meter and 4.0 meter above the rail track

- Rolling noise: 0.5 meter
- Traction noise: 0.5 and 4.0 m
- Aerodynamic noise: 0.5 and 4.0 m
- Impact noise: 0.5 m
- Squeal noise: 0.5 m
- Bridge noise: 0.5 m

Rail conversion / input database table

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Code	Description	P_mech	V_max	Weight	Length	Axles	/heelDiamete	eelDiameterC	/heelMeasur	BrakeCode	Axle Load	RefTransfer	RefContact	RefRoughnes	RefTraction	fAerodynamic
2		Empty vehicle definition	0	0	0	0	0	0	large	none	CastIronBlock		0	0	0	0	0
3	1	Example Vehicle 1	830	120	68	14.89	4	360	small	none	CastIronBlock	17	1	1	1	1	3
4	2	Example Vehicle 2	640	140	93.8	52.34	4	920	large	none	CastIronBlock	23	2	2	2	2	3
5	SNCF BB66400	Diesel loc	830	120	70	14.97	4	1100	large	none	CastIronBlock	18	6	6	3	3	3
6	SNCF CC72000	Diesel loc	2250	160	114	20	4	1140	large	none	CastIronBlock	29	6	6	3	4	3
7	RENFE Dloco	Diesel loc	1155	125	80	19.5	4	1000	large	none	CastIronBlock	20	3	6	3	5	3
8	NS6400 Dloco	Diesel loc	1180	125	82	14.4	4	1000	large	none	CastIronBlock	21	3	6	3	6	3
9	TKOJ JT42CWR/Class66	Diesel loc	2200	121	126	20.1	6	1120	large	none	ositeBlock-k	21	6	6	4	7	3
10	NS DM 90 DMU	DMU	640	140	94	52.3	4	920	large	none	Disc-Non-Trea	24	3	6	5	8	3
11	NS 1700 Eloco	ELoco	4560	140	86	17.6	4	1260	large	none	CastIronBlock	22	6	6	3	9	3
12	NS mat 64 EMU	EMU	508	140	82	52.1	4	920	large	none	CastIronBlock	21	3	6	3	10	3
13	RMR Cat 1	Block braked passenger				26	4		large	none	CastIronBlock		3	6	3	10	3
14	RMR Cat 2 (a)	ICM-III, ICR trailer, SNCF passenger, TEE				26	4		large	none	CastIronBlock		3	6	3	10	3
15	RMR Cat 2 (b)	ICR 1700, DDM-1 1800 loco, Belgian locos				18	4		large	none	CastIronBlock		6	6	3	9	3
16	RMR Cat 3	Disc braked passenger trains				26	4		large	none	Disc-Non-Tread		3	6	5	10	3
17	RMR Cat 4	Block braked freight trains variable l and no.				n	n		large	none	CastIronBlock		3	6	3	0	3
18	RMR Cat 5 (a)	DE1, DE2, DE3				25	4		large	none	CastIronBlock		3	6	3	8	3
19	RMR Cat 5 (b)	2200, 2300 locos				14	4		large	none	CastIronBlock		3	6	3	3	3
20	RMR Cat 5 (c)	2400, 2500 locos				13	4		large	none	CastIronBlock		3	6	3	3	3
21	RMR Cat 6	Diesel trains with disc brakes				26	4		large	none	Disc-Non-Tread		3	6	5	8	3
22	RMR Cat 7	Disc braked urban subway and rapid tram trains				15	3		medium	none	Disc-Non-Tread		3	6	5	10	3
23	RMR Cat 8 (a)	ICM IV, IRM				26	4		large	none	Disc-Non-Tread		3	6	5	10	3
24	RMR Cat 8 (b)	DDM 2/3				26	4		large	none	CastIronBlock		3	6	3	10	3
25	RMR Cat 9 (a)	TGV PBA type, power car				20	4		large	none	CastIronBlock		3	6	3	9	3
26	RMR Cat 9 (b)	TGV PBA type, trailer car adjacent to power				20	3		large	none	Disc-Non-Tread		3	6	5	0	3
27	RMR Cat 9 (c)	TGV PBA types, other trailer cars				20	2		large	none	Disc-Non-Tread		3	6	5	0	3
28	RMR Cat 10	ICE-3 type assuming no wheel dampers				25	4		large	none	Disc-Non-Tread		3	6	5	10	3
29																	
30	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description	Description
31	Vehicle Code short	Vehicle Type long description	Power in kW	Max speed in kmh	Weight in ton	Length in m	no of axles	in mm	diameter in m	Wheel measu	Brake type	load in kN	Ref to Vehicl	Ref to Conta	Ref to Wheell	Ref to Tract	Ref to AeroD
32																	
33	**Examples:**	**Examples:**							large,	none	CastIronBlo						
34	SNCF BB66400	open wagon, (side or end loading and flat floor)							medium, 500	WheelDampe	Composite						
35	SNCF CC72000	open wagon, (mineral or ballast wagon or							small,	Screens	Disc-Non-						
36	RENFE Dloco	closed wagon, (8 or more vents)								Others							
37	NS6400 Dloco	closed wagon, (sliding walls)															
38	TKOJ JT42CWR/Class66	isolated or refridgerator wagon															
39	NS DM 90 DMU	2-axle flat wagon, (stakes & dropdown side															
40	NS 1700 Eloco	2- or 3-axle flat wagon, (car carrier wagons)															
41	NS mat 64 EMU	2-axle flat or open wagon, fixed side boards															
42		4-axle (bogie) flat wagon, drop-down end															
43		4-axle (bogie) flat wagon, non-standard															
44		Wagon with opening roof															
45		Other non-standard wagons															
46		tank wagon (also with spherical silos)															
47		DMU - Diesel self-Motored passenger															
48		EMU - Electric self-Motored passenger															
49		diesel loco															
50		electric loco															

Vehicle Definition | Vehicle Transfer | Contact Filter | Wheel Roughness | Traction Noise - accelerating | Traction Noise - ...

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versus
Standard Calculation Method II

Propagation

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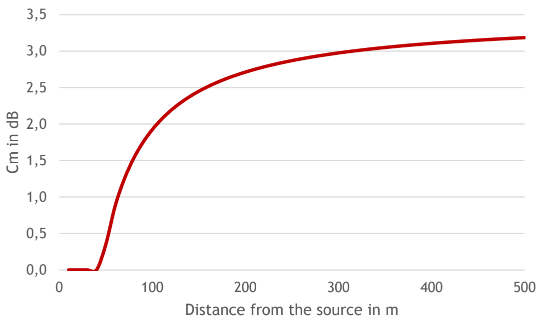
SRM 2 - Sound level in favorable conditions and a correction

Receiver calculations are made according to the following steps:

1. for each propagation path the calculation of the attenuation in favorable conditions

2. calculation of the long-term sound level for each path by using C_M

$$C_M = 3{,}5 - 35 \cdot \frac{h_{source} + h_{receiver}}{R}$$



3. accumulation of the long-term sound levels for all paths

CNOSSOS - Sound level in homogeneous and in favorable conditions

Receiver calculations are made according to the following steps:

1. on each propagation path:
    - calculation of the attenuation in favorable conditions
    - calculation of the attenuation in homogeneous conditions

$$L_{LT} = 10 \times \lg\left(p \cdot 10^{\frac{L_F}{10}} + (1 - p) \cdot 10^{\frac{L_H}{10}}\right)$$

2. calculation of the long-term sound level for each path by susing the percentage favorable (p %) and homogeneous conditions (100 - p %)

3. accumulation of the long-term sound levels for all paths

dGm[R]

CNOSSOS - Propagation

$$L_{LT} = 10 \times \lg\left(p \cdot 10^{\frac{L_F}{10}} + (1-p) \cdot 10^{\frac{L_H}{10}}\right)$$

$$L_H = L_{w,o,dir} - (A_{div} + A_{atm} + A_{boundary,F})$$

$$L_F = L_{w,o,dir} - (A_{div} + A_{atm} + A_{boundary,H})$$

A_{div} is the attenuation due to geometrical divergence

A_{atm} is the attenuation due to atmospheric absorption

$A_{boundary,F/H}$ is the attenuation in favorable/homogeneous conditions. It contains the following:

- $A_{ground,F/H}$ which is the attenuation due to the ground in favorable/homogeneous conditions
- $A_{dif,F/H}$ which is the attenuation due to diffraction in favorable/homogeneous conditions

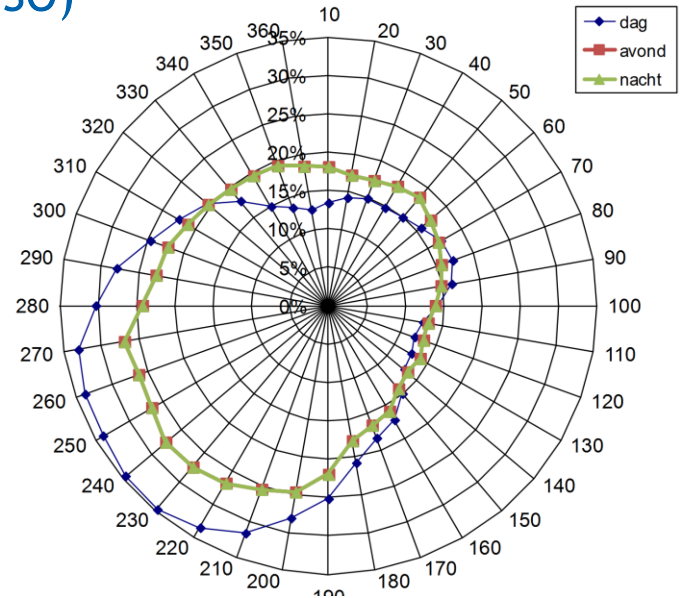
CNOSSOS - Propagation and meteo

2 calculations

- Homogeneous: straight rays
- Favourable: curvature 8R (equivalent to ISO)

Method to calculate $\%_{\text{favoured per period}}$

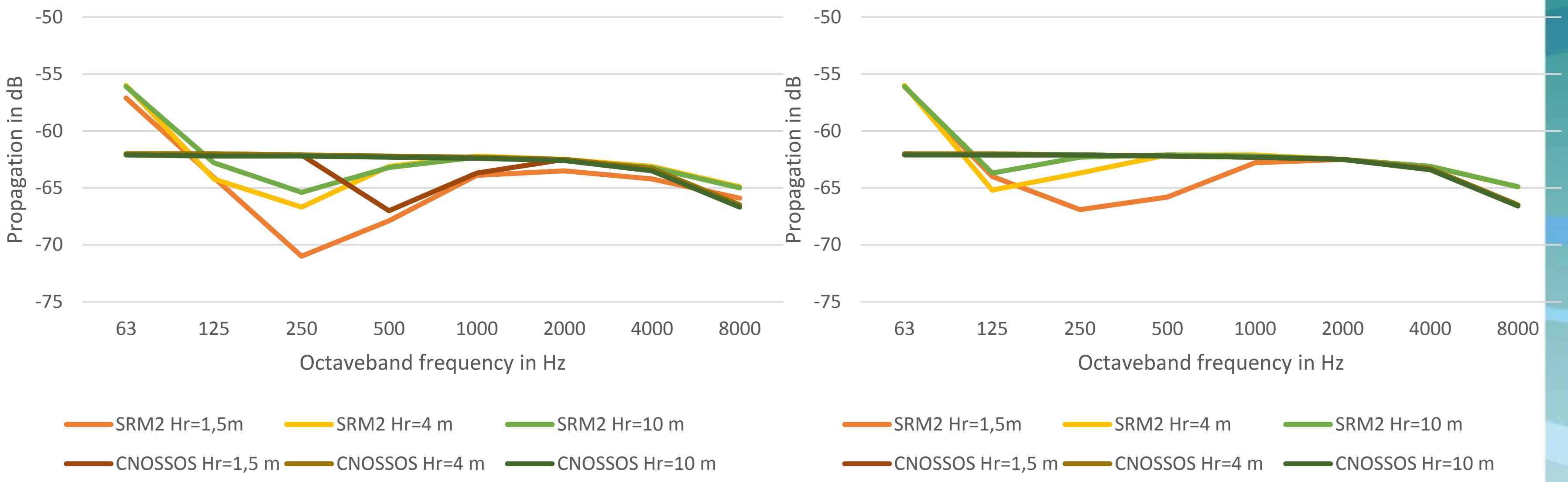
This method replaces the C_m correction according to ISO and the Dutch calculation method



G values for different types of ground

Description	Type	(kPa · s/m²)	G value
Very soft (snow or moss-like)	A	12,5	1
Soft forest floor (short, dense heather-like or thick moss)	B	31,5	1
Uncompacted, loose ground (turf, grass, loose soil)	C	80	1
Normal uncompacted ground (forest floors, pasture field)	D	200	1
Compacted field and gravel (compacted lawns, park area)	E	500	0,7
Compacted dense ground (gravel road, car park)	F	2 000	0,3
Hard surfaces (most normal asphalt, concrete)	G	20 000	0
Very hard and dense surfaces (dense asphalt, concrete, water)	H	200 000	0

Propagation to a microphone at 50 m



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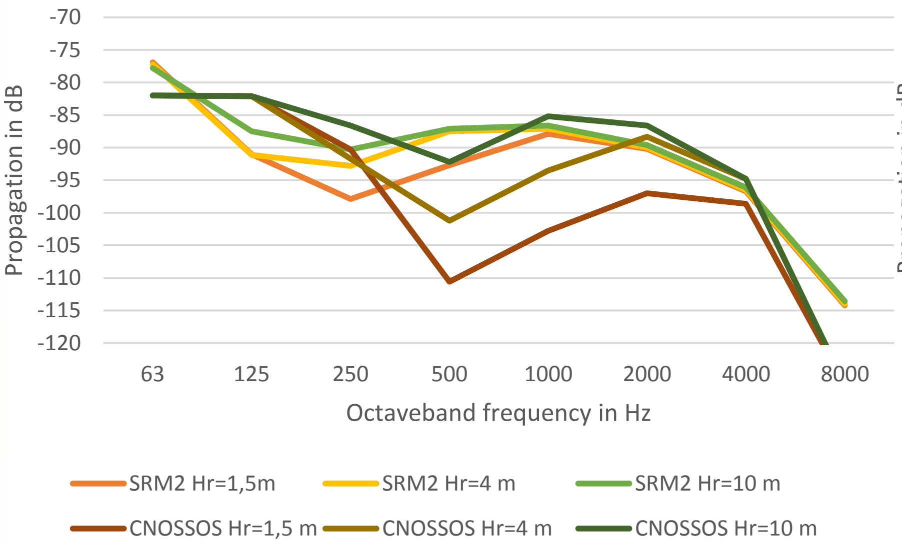
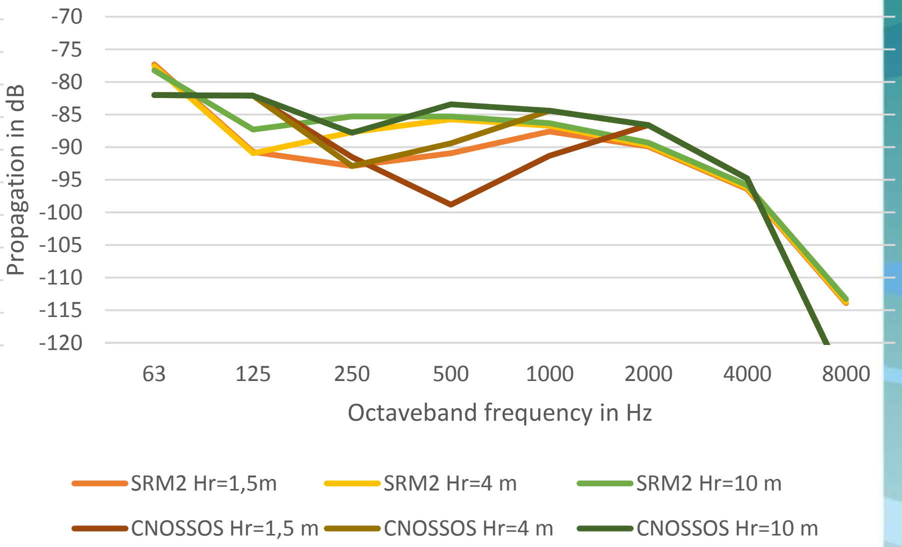
Propagation to a microphone at 500 m





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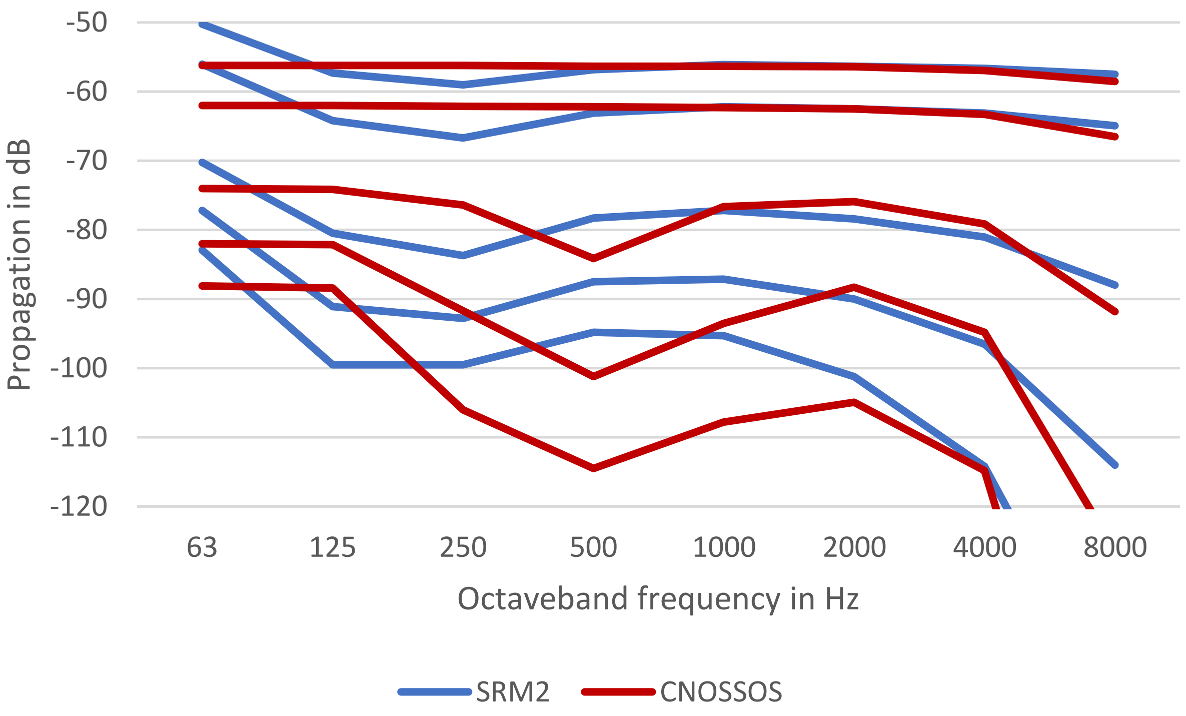
Propagation of a source at 0,5 m height to a microphone at 25, 50, 200, 500, 1000 m, 4 m above the ground



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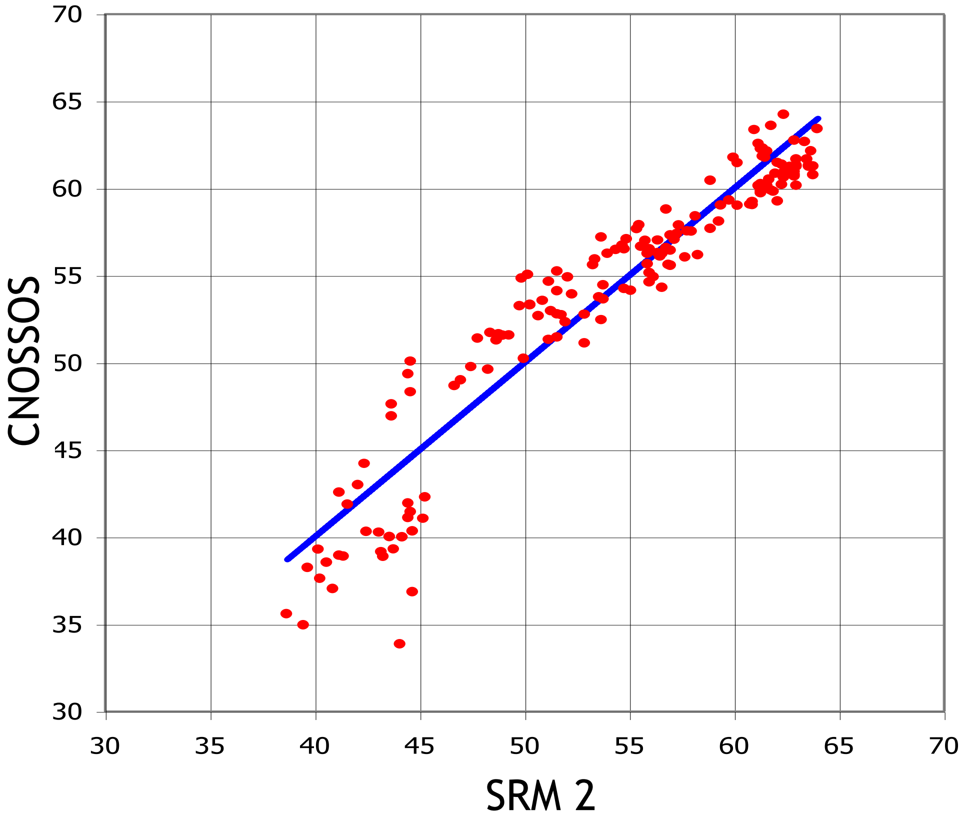
CNOSSOS - SRM 2



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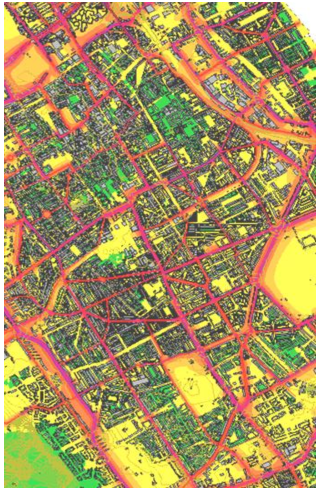
versus
Standard Calculation Method II

Conclusions

Recommendations

Conclusions

- A simpler source model by using only two source heights
- In the source more aspects as traction noise and curve squeal
- Rail conversion tables
- Extra input data on meteo
- CNOSSOS will give
    - somewhat higher levels for reflective ground
    - somewhat lower levels for absorptive ground
- Source power determination should be according to inverse propagation calculation



Recommendations

Define the field of application in your MS:

- ✓ Strategic noise maps and action plans
- ✓ Assessment and legislation

Check your emissions:

- o Define your vehicles

Anticipate the public on new calculation results

- More reliable and more state-of-the-art
- What’s in it for me
- What is the best method for reducing noise levels

Calculate round 3 (now 2018) with the old method and with CNOSSOS

Thanks for your attention

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