INFRABEL
Right On Track

Noise efficient, sustainable, track design, monitoring and asset management at Infrabel

Ward Verhelst, I-AM.236

Vienna, 13.10.2016

Introduction

"Noise efficient, sustainable track design, monitoring and asset management at Belgian INFRABEL Network"

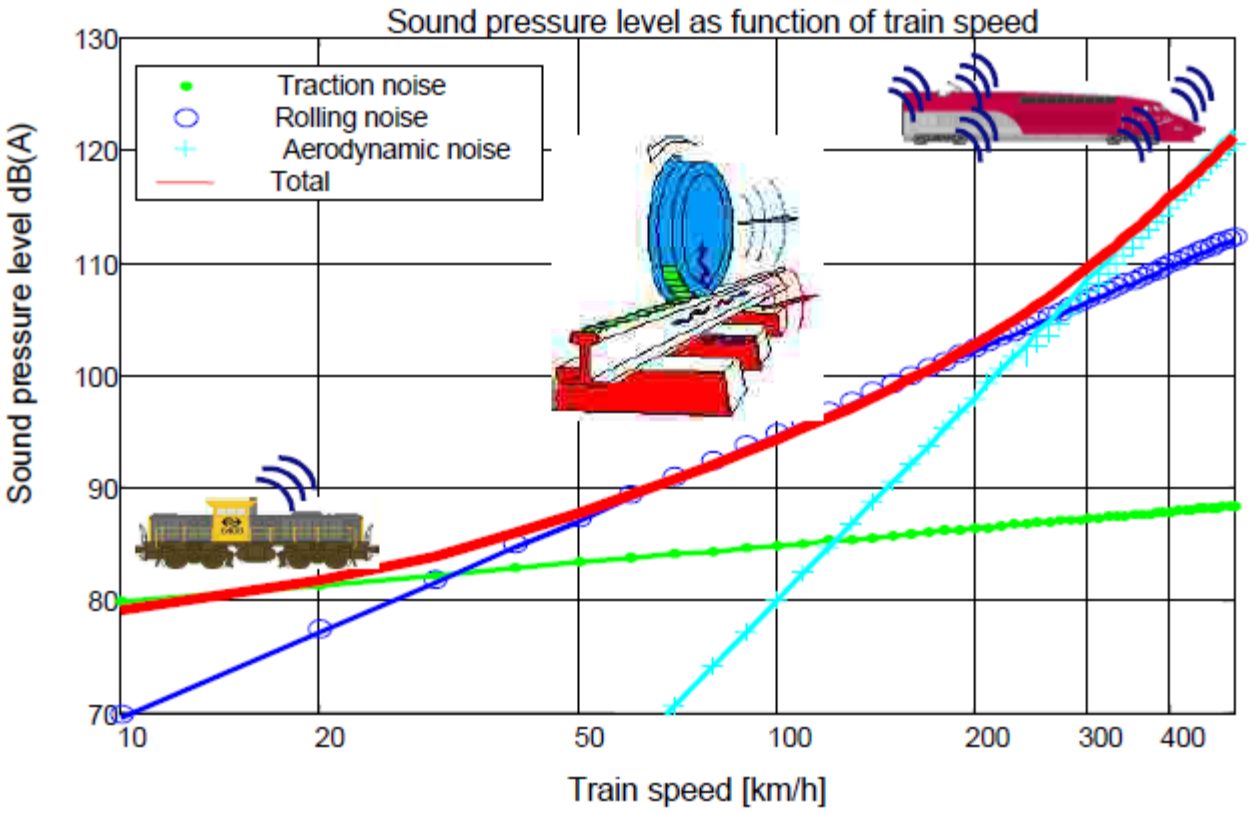
- By combining efficient track design, maintenance, and monitoring a substantial reduction on rolling noise can be achieved.

- Results and experiences based on large measurement campaigns and not on pure modelling proof that Railway noise emission can be further reduced 2.5 - 4 dB for a minimum cost.

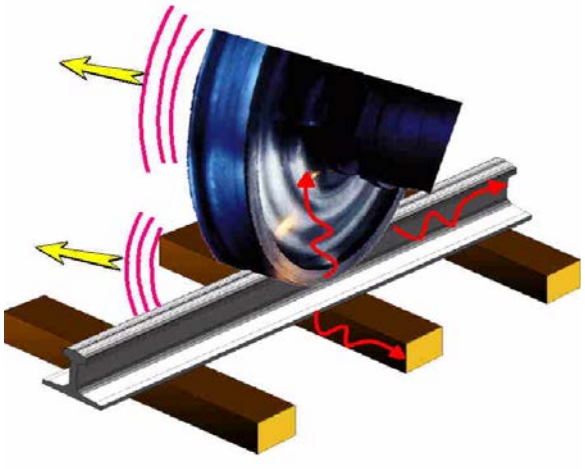
Content

- Basics Rolling noise: interaction track / rolling stock
- Track (rail pad) design: effects on noise
- Noise Monitoring of Infrastructure and Rolling stock
- Asset management: rail grinding: effect on noise
- Conclusion

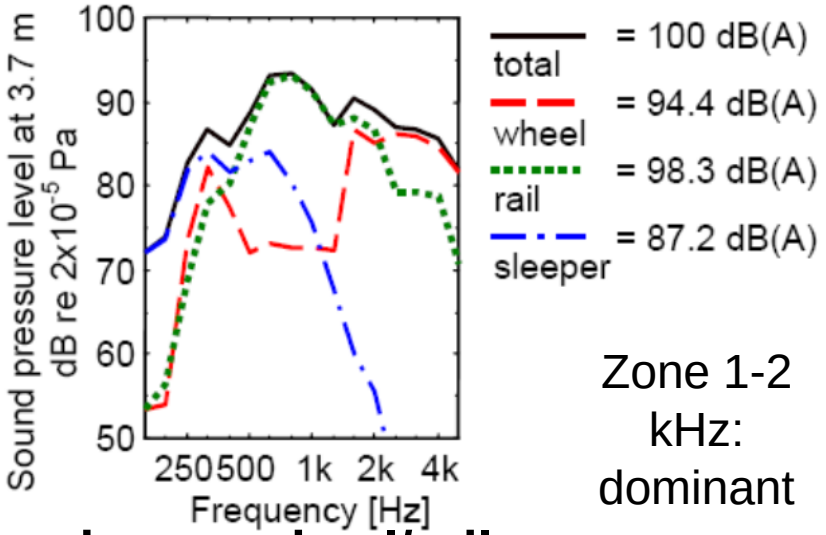
Basics Rolling noise: interaction track / rolling stock



Basics Rolling noise: interaction track / rolling stock



Prediction for a freight wheel on track with medium stiffness rail pads.



Zone 1-2 kHz: dominant

1) **Excitation by roughness wheel/rail**

2) **In many cases rail contribution is dominant**

3) **Try to control rail vibration -> how: track design?**

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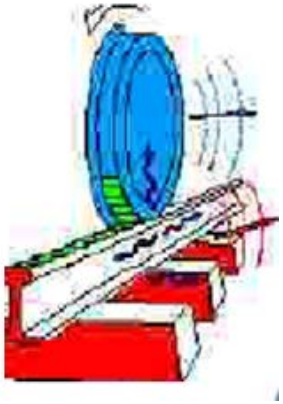
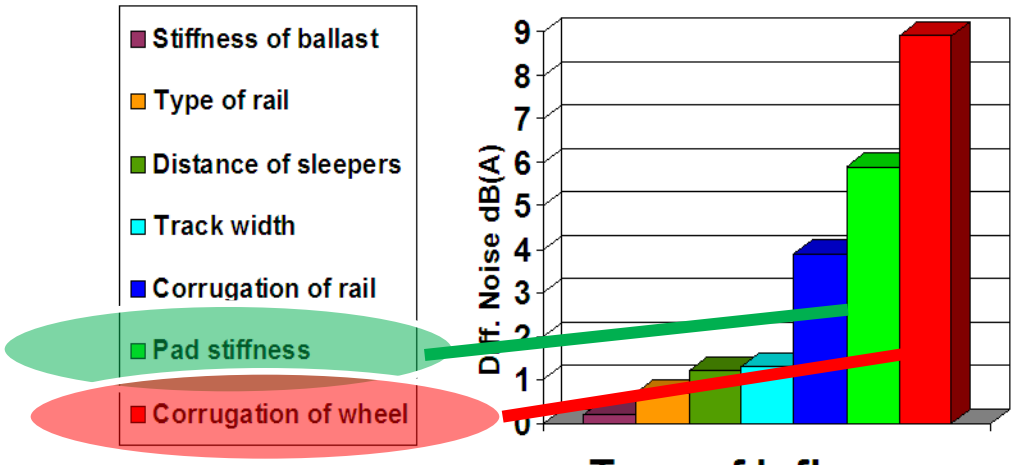


Influence on Noise



Type of Influence

Cast iron

LL/K blocks

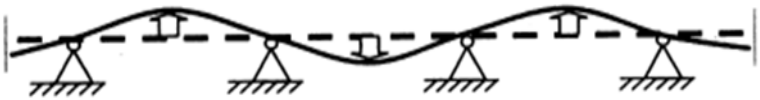
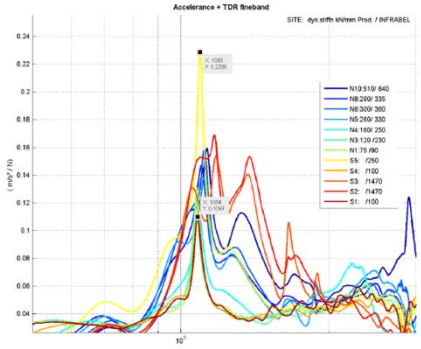


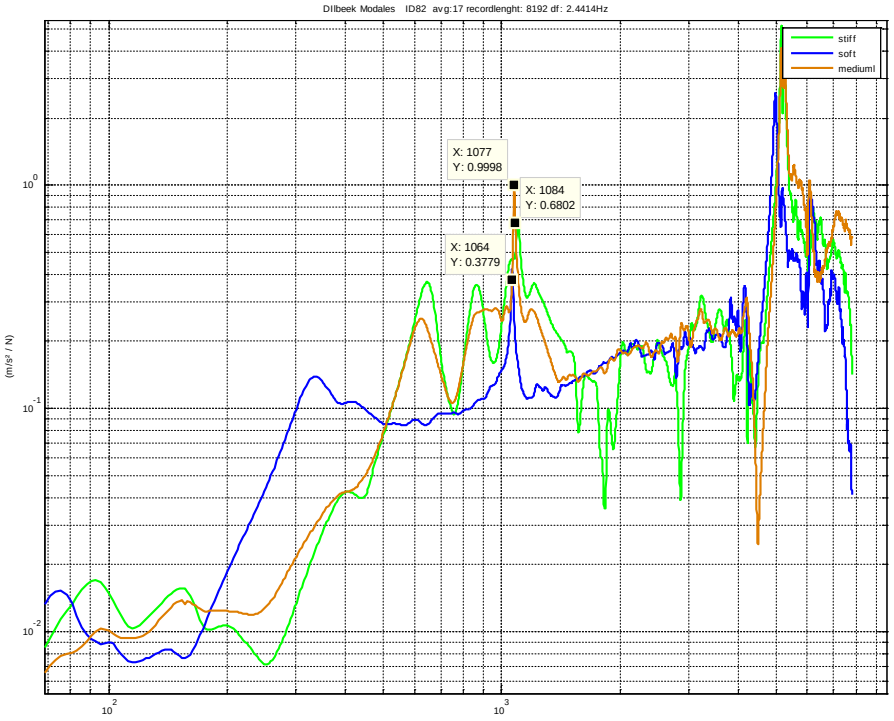
Fig. 1. Pin-pin vibration mode (first mode).

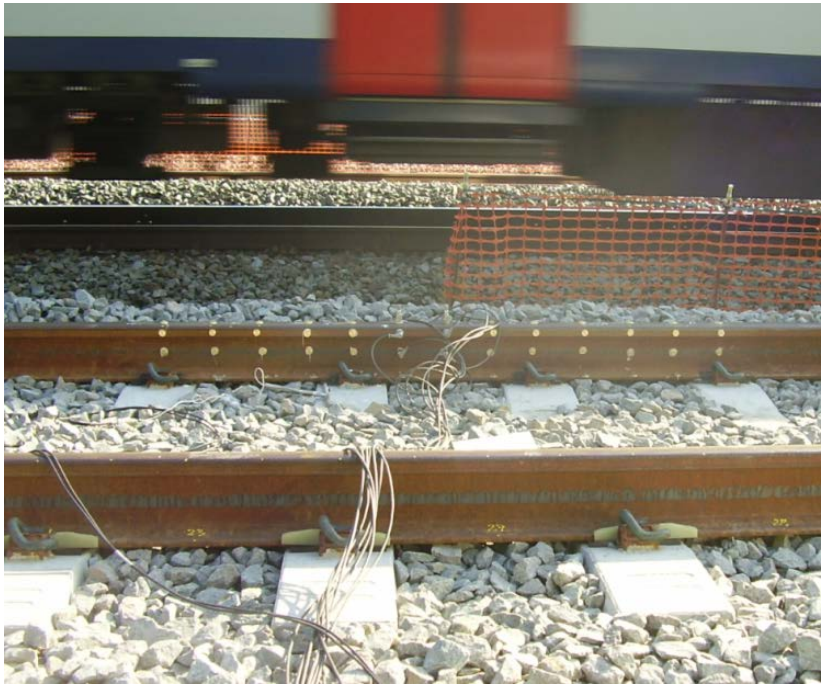
Track design: effects on noise

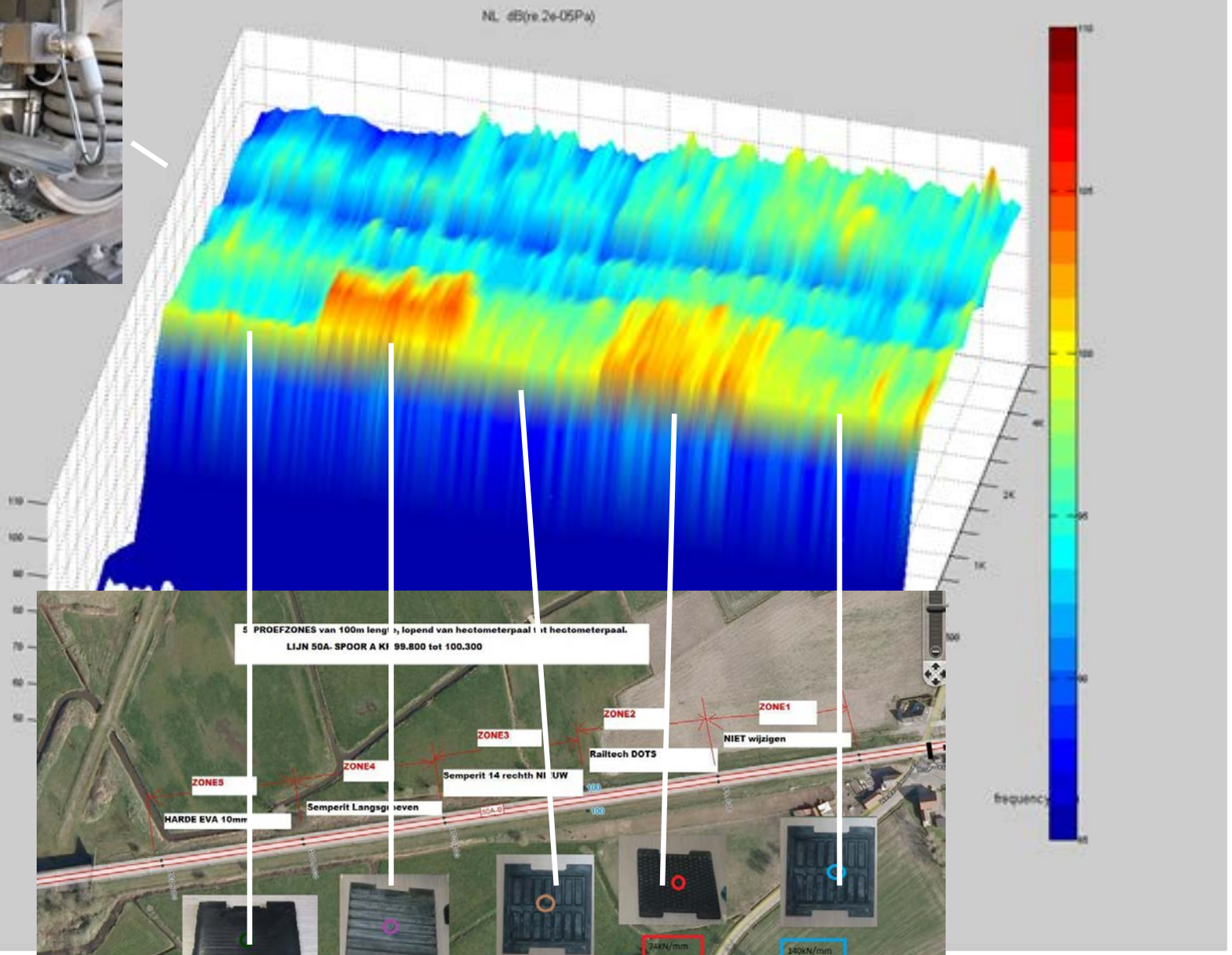


- Focus on the railpad
  - Why: only component in contact with rail
  - goal: not by extreme stiffening (distribution of forces in ballast)
  - Maximum of damping restrict “ pin-pin”mode of rail
  - Design and validate shape of the railpad

- How
  - modelling? Lab test? or implement and test in track
  - Advantage of in situ tests:
    - *real situation*
    - *ISO norms to test performance (ISO3095, ISO15641)*
    - *Direct effect on noise can be measured*


Dilbeek Modales ID82 avg:17 recordlenght: 8192 df: 2.4414Hz
stiff
soft
mediuml
X: 1077
Y: 0.9998
X: 1084
Y: 0.6802
X: 1064
Y: 0.3779
(m/s² / N)
10^0
10^-1
10^-2
10^2
10^3




NL dB(re.2e-05Pa)
PROEFZONES van 100m lengte, lopend van hectometerpaal tot hectometerpaal.
LIJN 50A- SPOOR A KM 99.800 tot 100.300
ZONE1
NIET wijzigen
ZONE2
Railtech DOTS
ZONE3
Semperit 14 rechth NIEUW
ZONE4
Semperit Langsgroeven
ZONE5
HARDE EVA 10mm
frequency
74kN/mm
140kN/mm
124kN/mm
100kN/mm
470kN/mm

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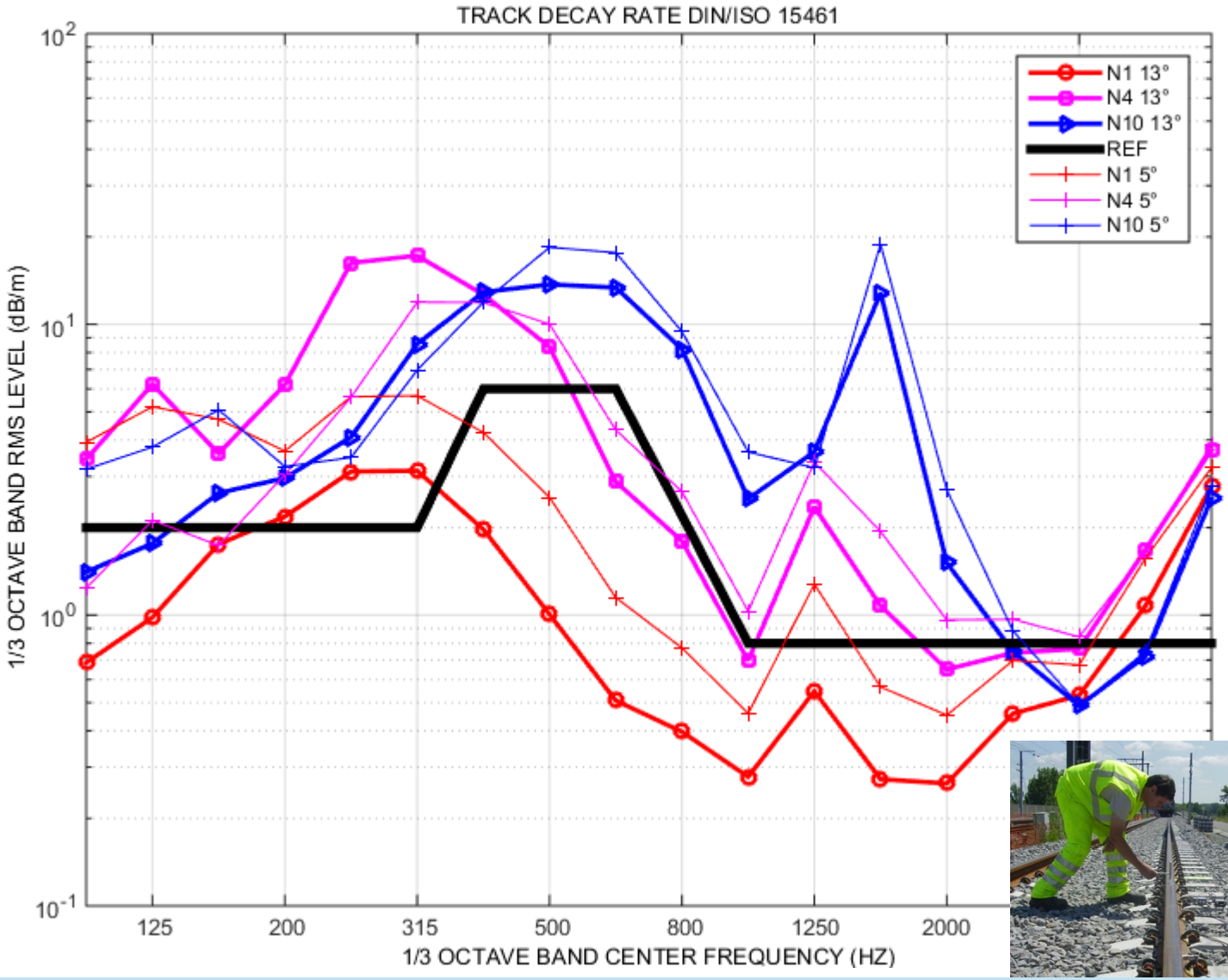
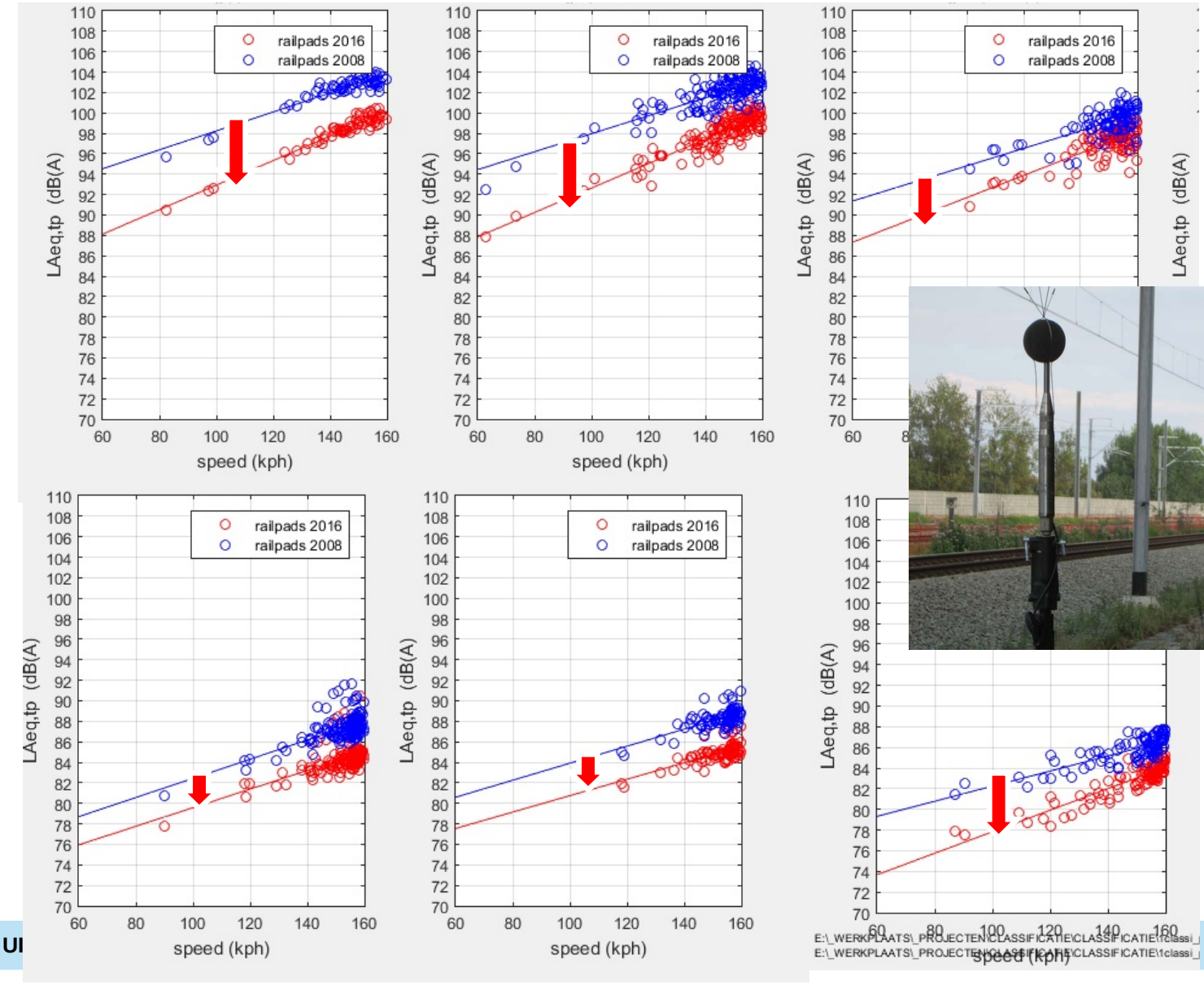
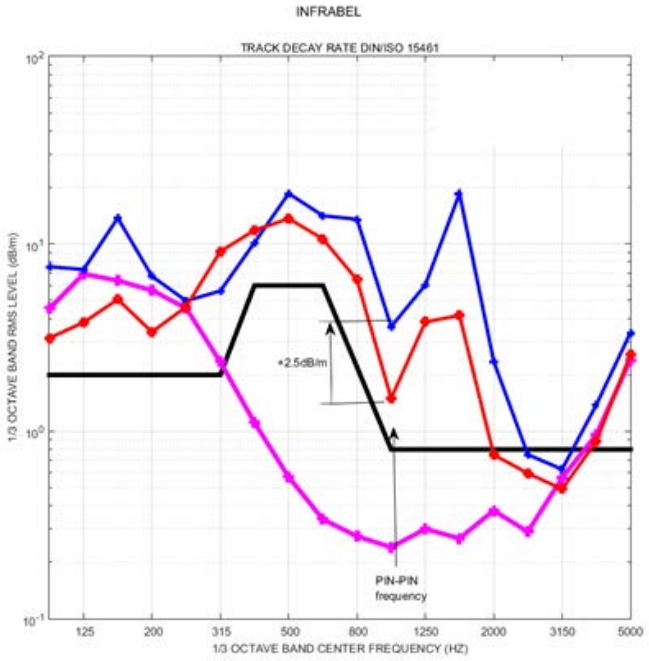

TRACK DECAY RATE DIN/ISO 15461
1/3 OCTAVE BAND RMS LEVEL (dB/m)
1/3 OCTAVE BAND CENTER FREQUENCY (HZ)
N1 13°
N4 13°
N10 13°
REF
N1 5°
N4 5°
N10 5°


railpads 2016
railpads 2008
LAeq,tp (dB(A)
speed (kph)
E:_WERKPLAATS_PROJECTEN\CLASSIFICATIE\CLASSIFICATIE\1classi_

Track design: effects on noise

Modification of technical specification L-63 for Railpads

- *Introduction of TDR (EN 15461) measurement in qualification process.*
- *A test track will be foreseen in qualification*
- *Temperature variation taken into account*



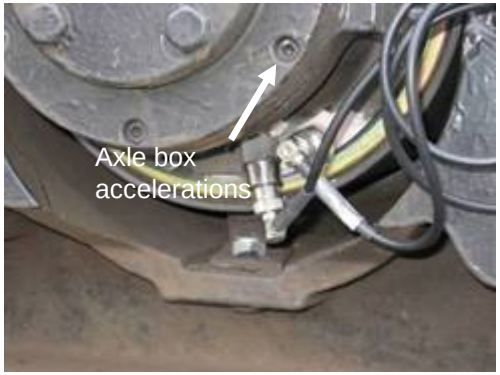
Noise Monitoring Infrastructure and Rolling stock

- Monitoring track emission by means of a “monitoring train”
  - Instrumented train that runs over complete network
  - Multiple purpose: rail emission, hot spots, grinding quality

- Monitoring train emission by means of a “monitoring track”
  - Combination of “W.I.M” and N&V emission in dedicated locations
  - Automated brake block detection

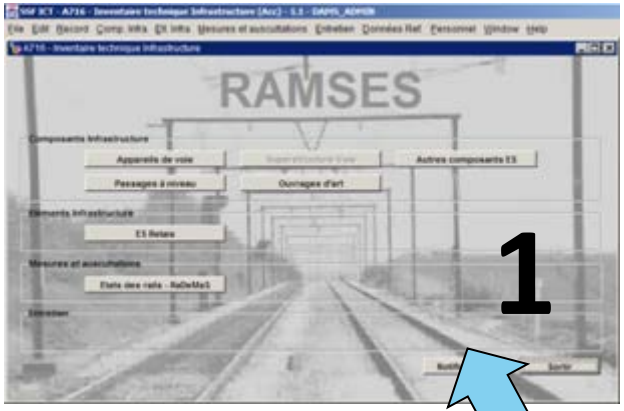
Noise Monitoring Infrastructure

- Permanent Installation of N&V sensors on the EM130 measurement train since 2011
- Logging of the entire Infrabel network 2 times a year
  - Accelerometers (4) on the axle boxes
  - Microphones (2) to capture Wheel-Rail Noise emission
  - Logging of position with DGPS (10Hz)
  - A/D, measurement control, and post-processing, and data management with MATLAB
- Data visualisation available in:
  - Google earth (on train post-processing)
  - GeoRamses (see further)

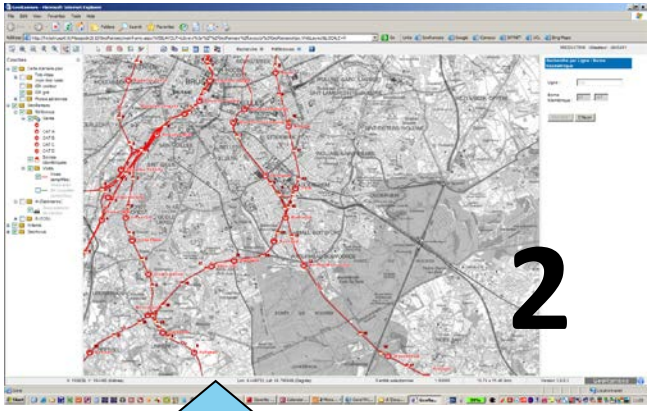


Visualization in GeoRamses

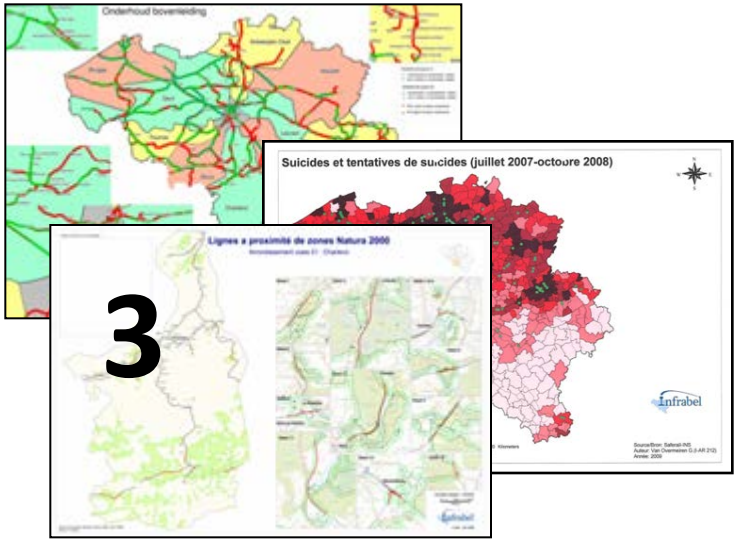
Data input (since 1996)

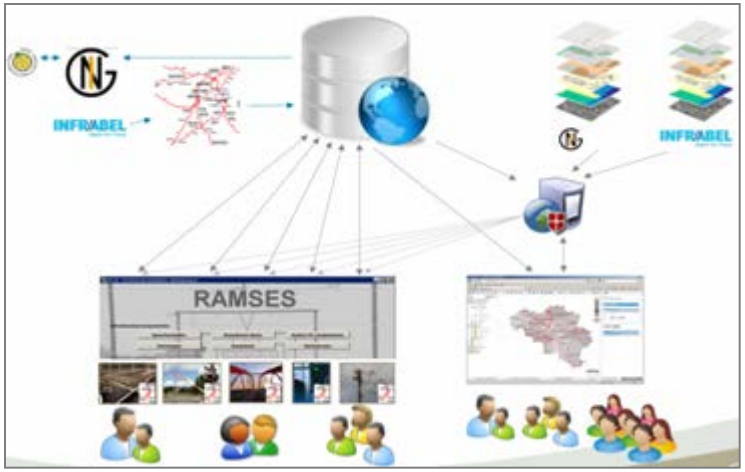


Publication on Intraweb (2009)

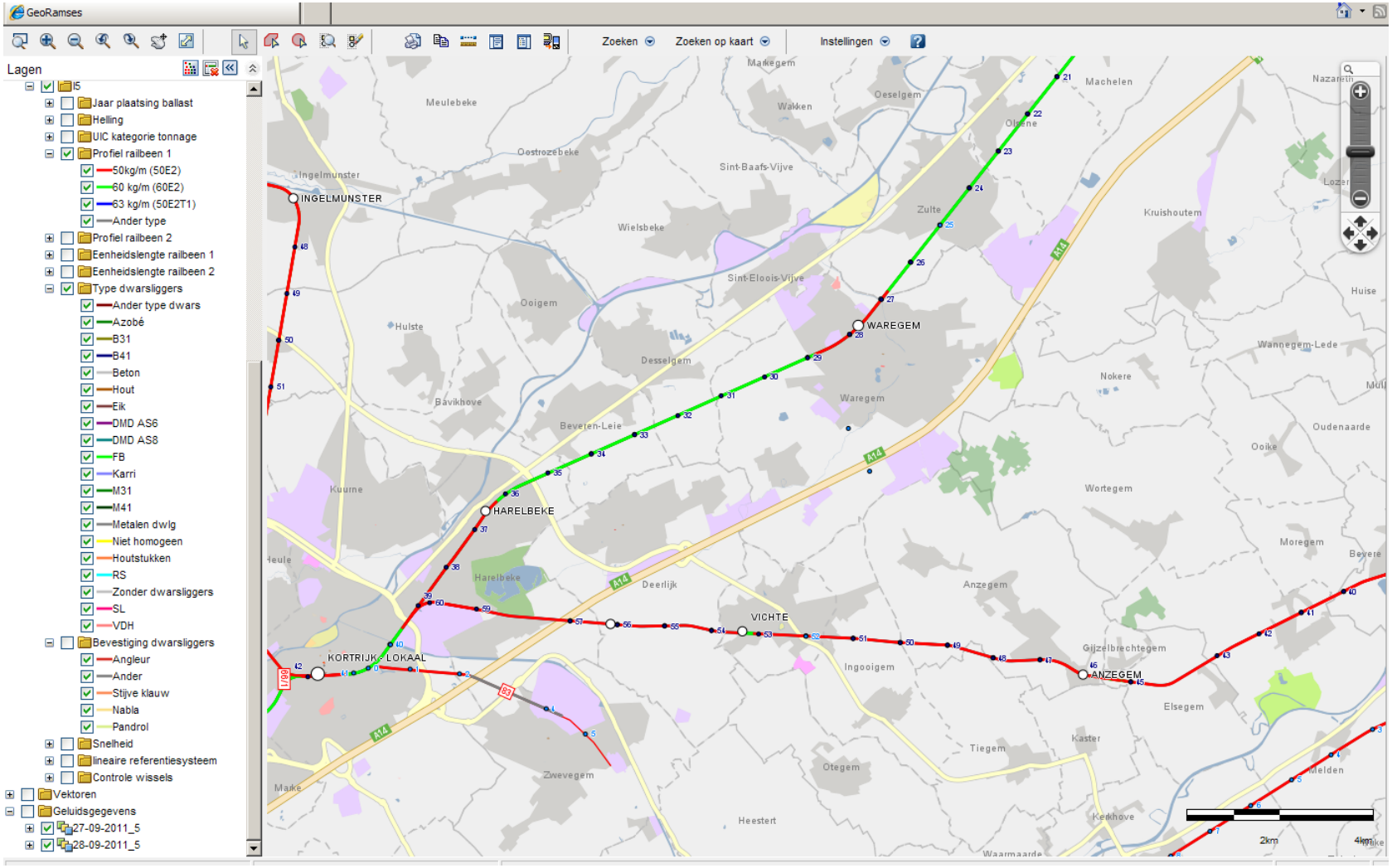


Specific applications 2010

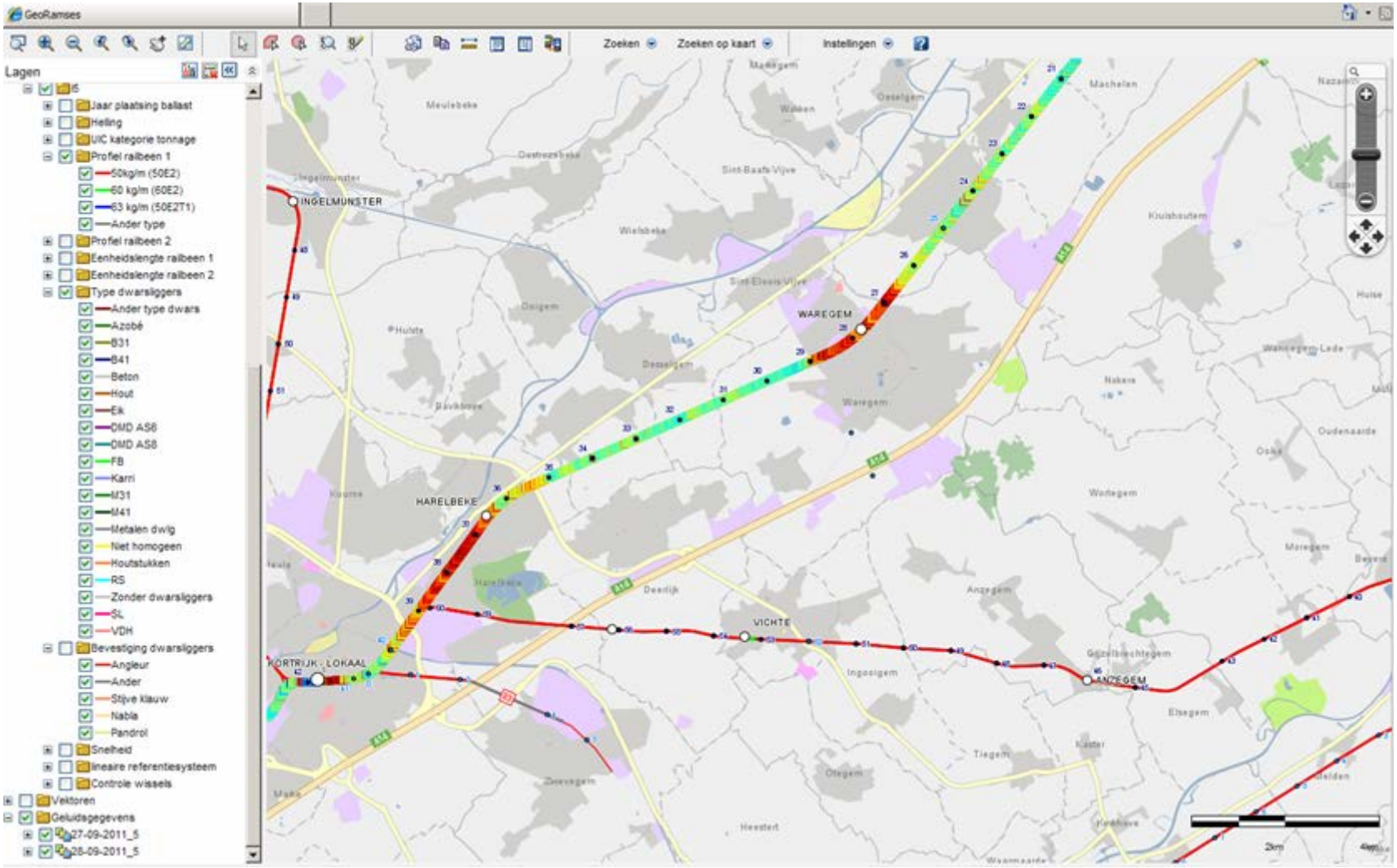




Visualization in GeoRamses

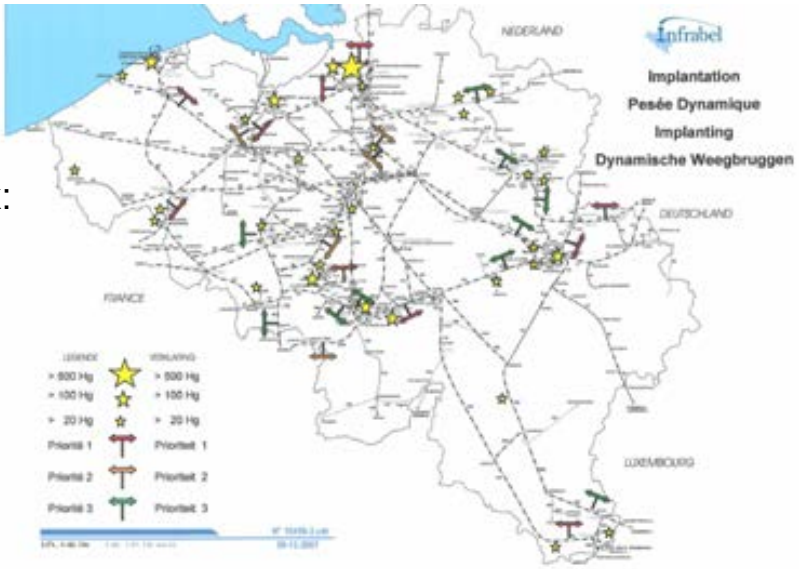


Visualization in GeoRamses



(Noise) Monitoring Rolling stock

WIM: Weight in motion



2011: Initial project requirements (I-TMS.51)

- cover more than 90% of the complete rolling stock: 15 installations on double track = 30 measurement positions
- W.I.M. installations for: axle load weighting, Load distribution over wheels/axles,…, dynamic loads (impacts, wheelflats,..)

Additional demand (I-AM.236)

- one complete year of testing
- N&V measurement will be included to build up a database with train TEL level - ISO 3095 + raw N&V data
- Post processing with TNO-PBA software will lead to dBase with acoustic quality of rolling stock

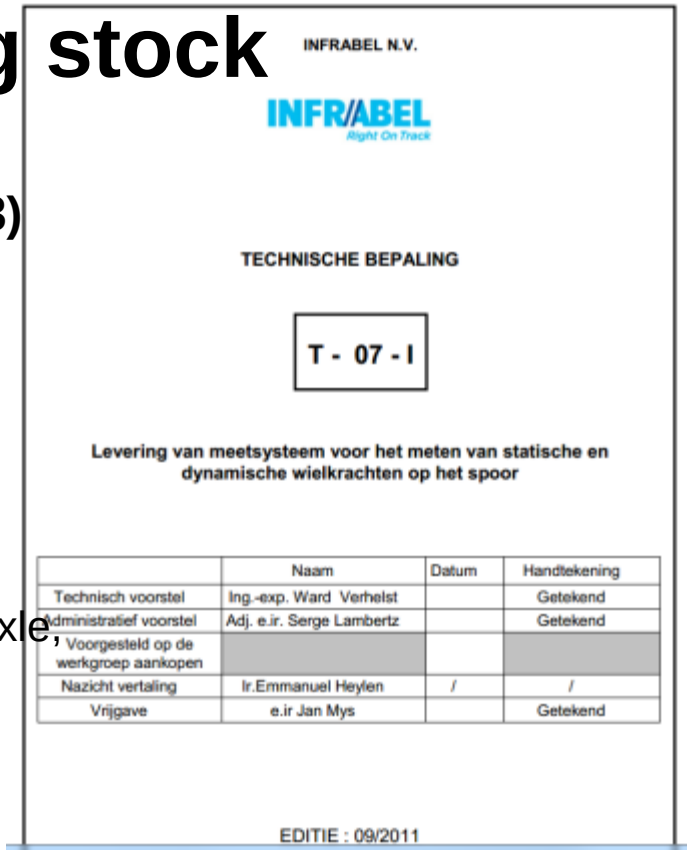
(Noise) Monitoring Rolling stock

2011: Tender: Technical specification (by I-AM.23)

- <30 ton /axle
- Available after 30s
- 2400 axle/hour
- +/- 5% trainweight
- 10% axle loads (30-120km/h)
- Dynamic forces
- Timestamp train identification
- Total trainweight + individual detection of vehicle, axle, wheel parameters

ADDED

- Min. 7 meter measurement area (prEN 15654-3)
- LAeq,tp according to ISO 3095 + storage **raw rail acceleration+microphone data**



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TECHNISCHE BEPALING

T - 07 - I

Levering van meetsysteem voor het meten van statische en dynamische wielkrachten op het spoor

	Naam	Datum	Handtekening
Technisch voorstel	Ing.-exp. Ward Verhelst		Getekend
Administratief voorstel	Adj. e.ir. Serge Lambertz		Getekend
Voorgesteld op de werkgroep aankopen			
Nazicht vertaling	Ir.Emmanuel Heylen	/	/
Vrijgave	e.ir Jan Mys		Getekend

EDITIE : 09/2011

(Noise) Monitoring Rolling stock

Organisation of 4 qualification tests (2014)

Why

- Influence of temperature
- Stability in time
- % deviation on measured parameters
- Influence of settlement and foundation layers
- Relation between speed and dynamic forces
- Influence of passage direction

How

Arrangement of a specific test train with

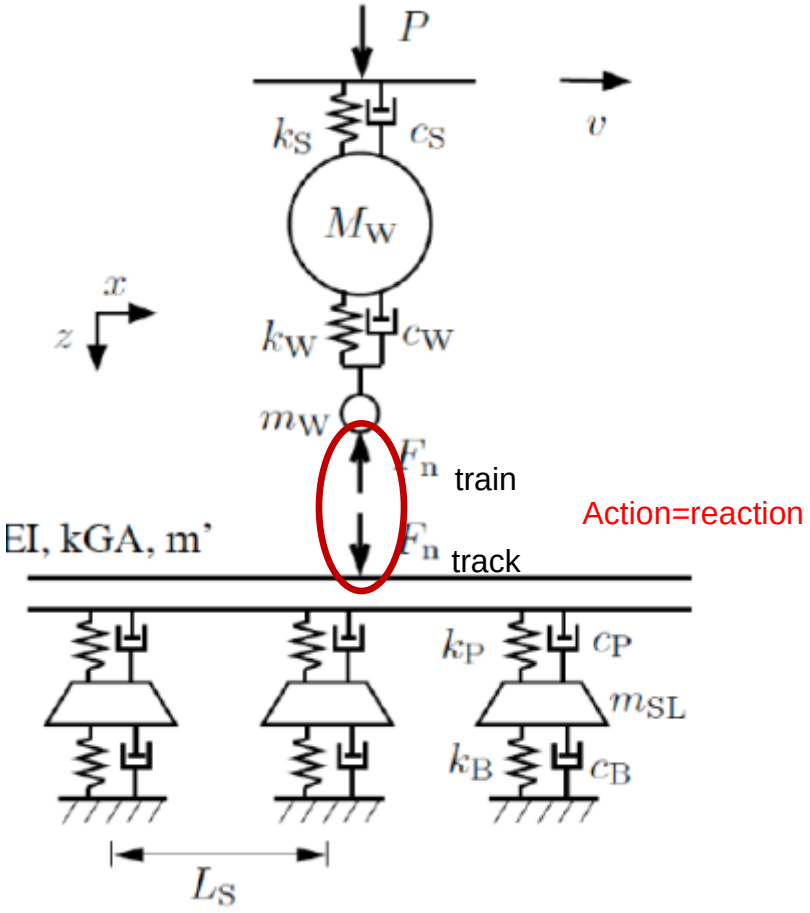
- Known axle loads (< 1%)
- Known Wheel roughness
- Manual induced wheel errors

  wheel flats: 2 x 60mm, 2 x 30mm at different static axle loads
- Several passages in 2 directions (0/1) at 4 speeds: 20,40,60,80km/h

L75: De Pinte

Test train: dynamic forces

$F_N = m_{wheelset/2} * a$



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TNO – PBA software

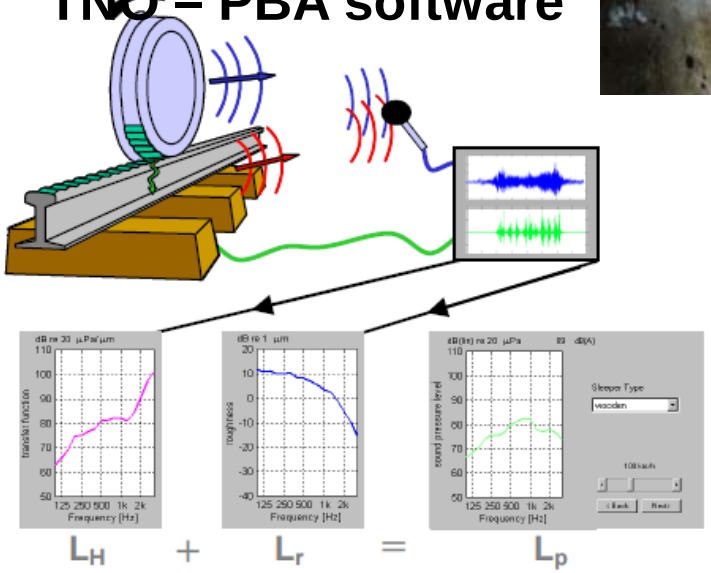


Figure 1.2: Schematic overview of the analysis procedure with a typical result. Total roughness and total transfer function can be used to calculate the total sound pressure at a given train speed.

>5kHz:glueing sensor on rail!!

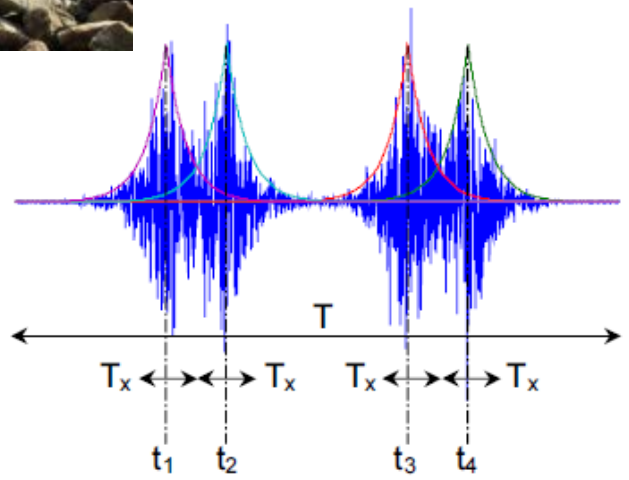


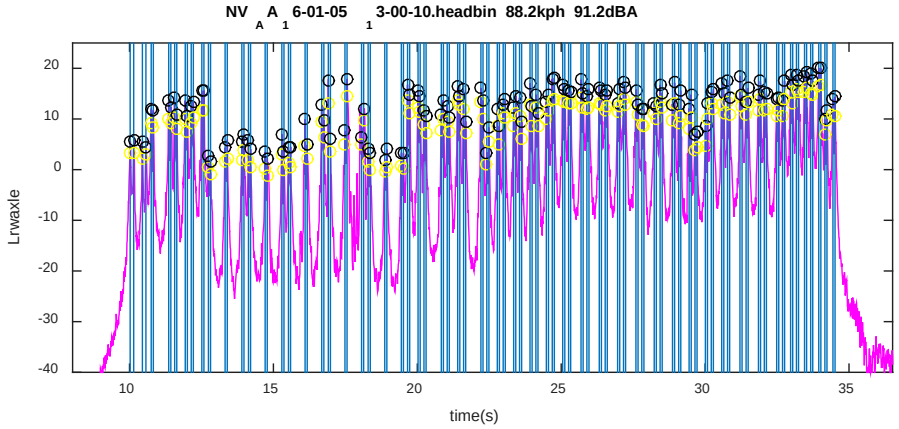
Figure 3.1 Vertical acceleration measurement during four wheel passages.

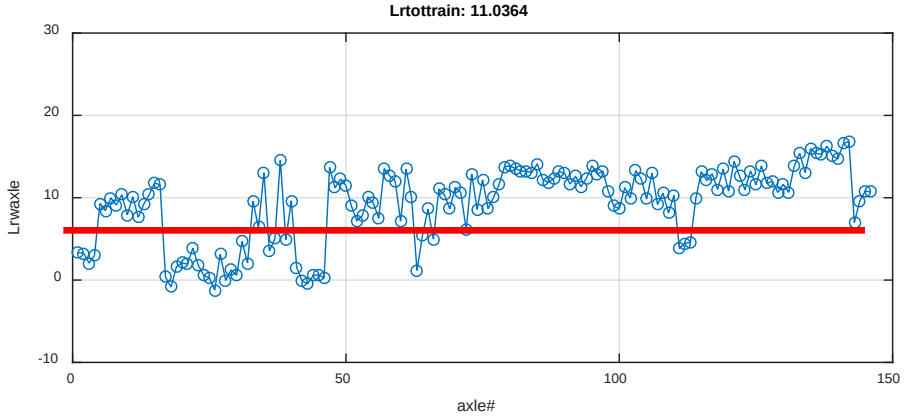
Single value indicator for roughness

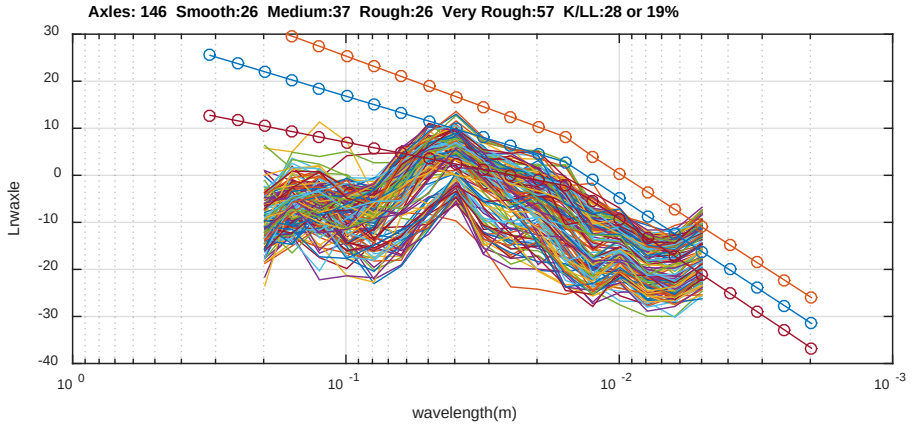
$L_{\lambda CA}$ (Harmonoise project (2003)

$$L_{\lambda CA} = 10 \log \sum_{\lambda=20\,cm}^{0,4\,cm} 10^{\frac{1}{10}\{R(\lambda)+\Lambda(\lambda)+C(\lambda)+A(f(\lambda,v))\}}$$

0 – 4 dB “smooth rail”
5 – 7 dB “ground rail” (approx. 1 month after grinding)
7 – 9 dB average rail roughness (average of 30 Dutch sites [6])
10 –11 dB “smooth wheels” (unbraked, disc-braked, or sinter blocks ([6]);
12 dB average rail roughness of the Dutch network in calculation scheme [15];
14 –17 dB corrugated rail;
18 –20 dB “rough wheels” (cast-iron blocks, disc+additional cast iron blocks)
25 –28 dB severely corrugated track

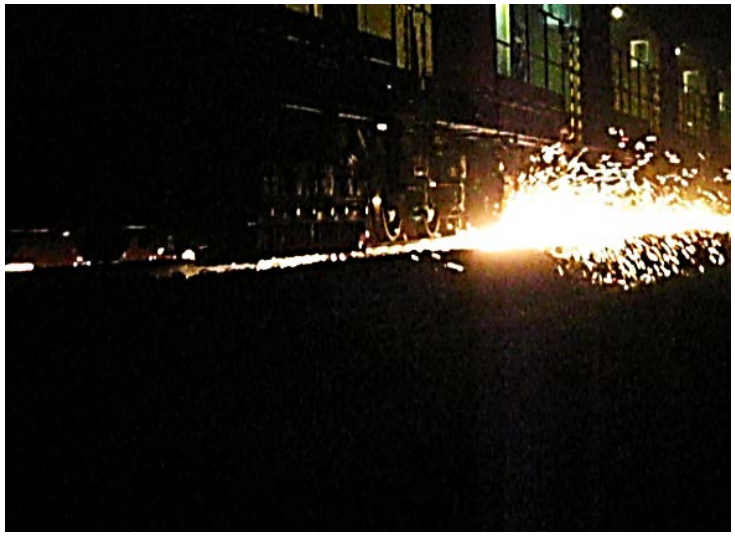

NV A 1 6-01-05 1 3-00-10.headbin 88.2kph 91.2dBA
Lrwaxle
time(s)


Lrtottrain: 11.0364
Lrwaxle
axle#


Axles: 146 Smooth:26 Medium:37 Rough:26 Very Rough:57 K/LL:28 or 19%
Lrwaxle
wavelength(m)

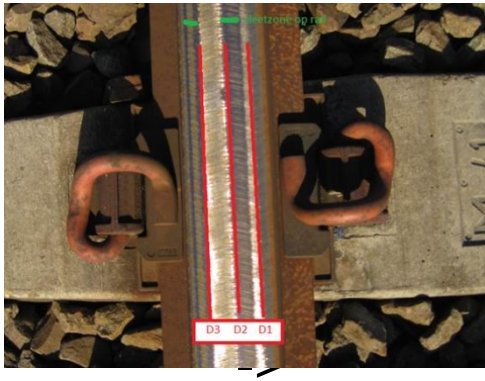
Visual validation running train:
High speed camera

Asset management: Adapted Rail grinding: effect on noise



2 types of grinding:

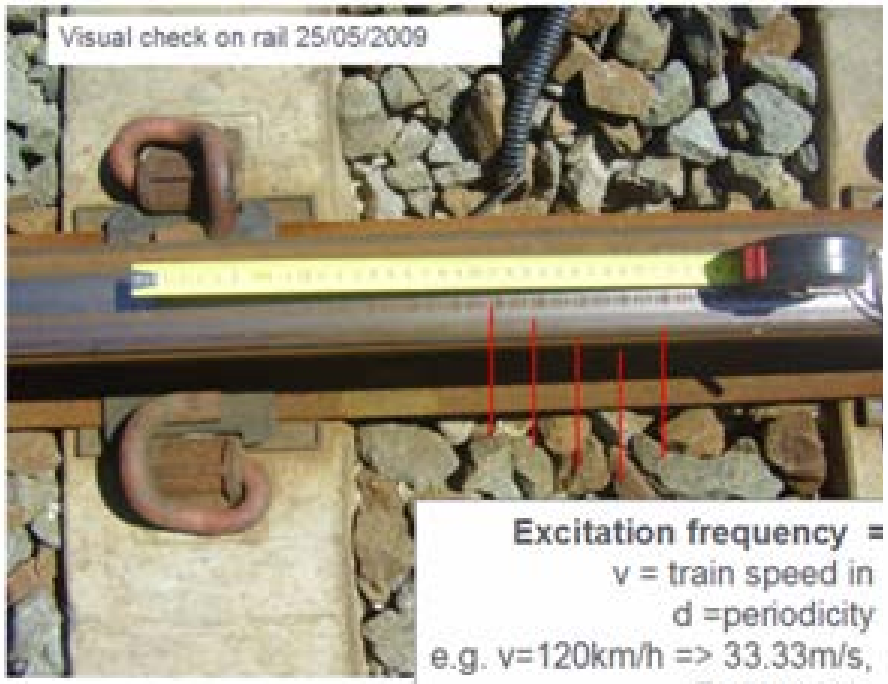
- Curative grinding: >0.3mm
- - 5km/h
  - Heavy Rail surface defects
  - Corrugation
- Preventive or cyclic grinding: 2 x 0.15mm
- - **12-14km/h (since 2014-2015)**
  - To prevent build up of head checks and minor errors
  - All UIC 1-6 class lines

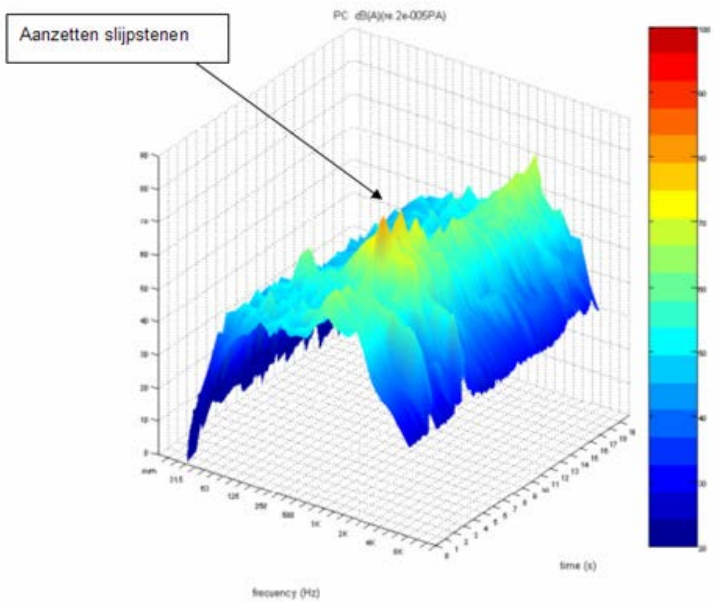


Since 2011 tests at higher grinding train speeds: why??
Grinding track in service, today systematic planned

- Evaluation by noise and roughness monitoring, before, during and after grinding

Rail Grinding: Effect on noise emission

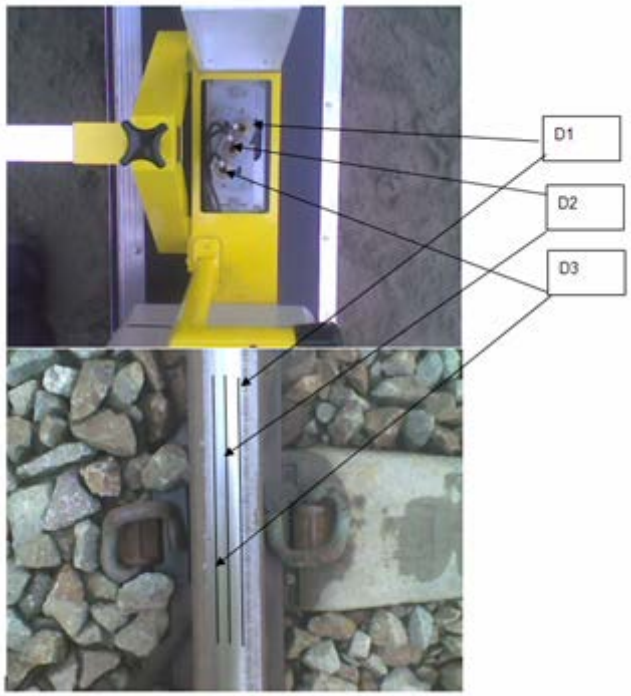


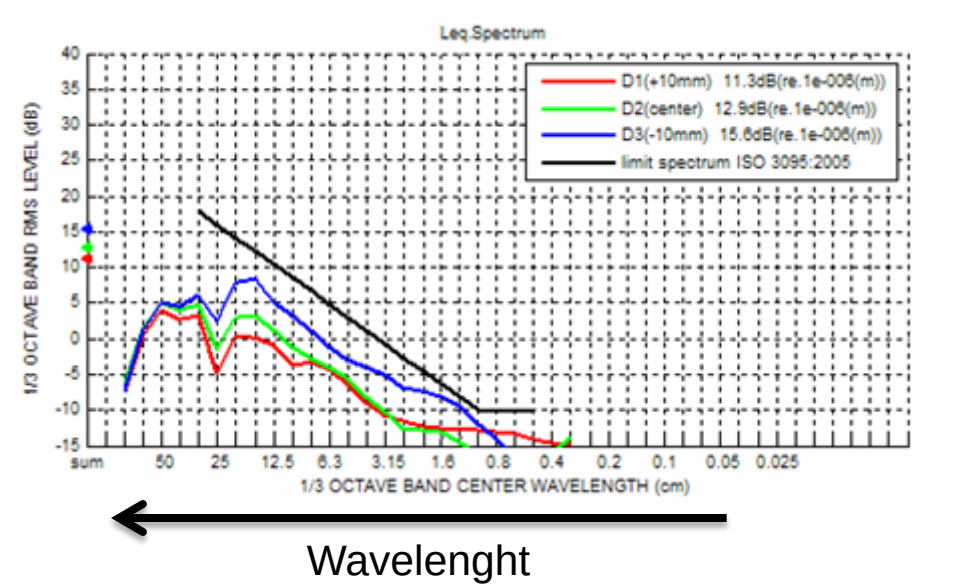


1kHz-2kHz: Low TDR, Presence of PIN-PIN mode -> High emission and tonal noise!!

Rail Grinding: Effect on noise emission

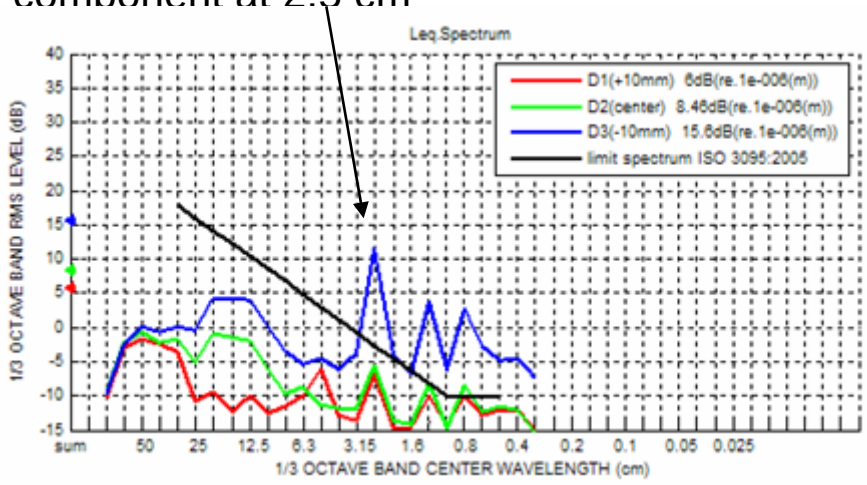
Roughness



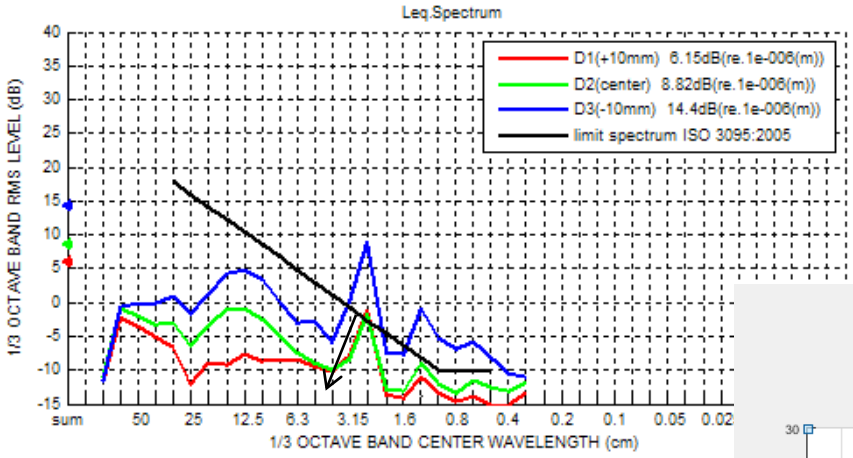


Wavelenght

After grinding: tonal component at 2.5 cm

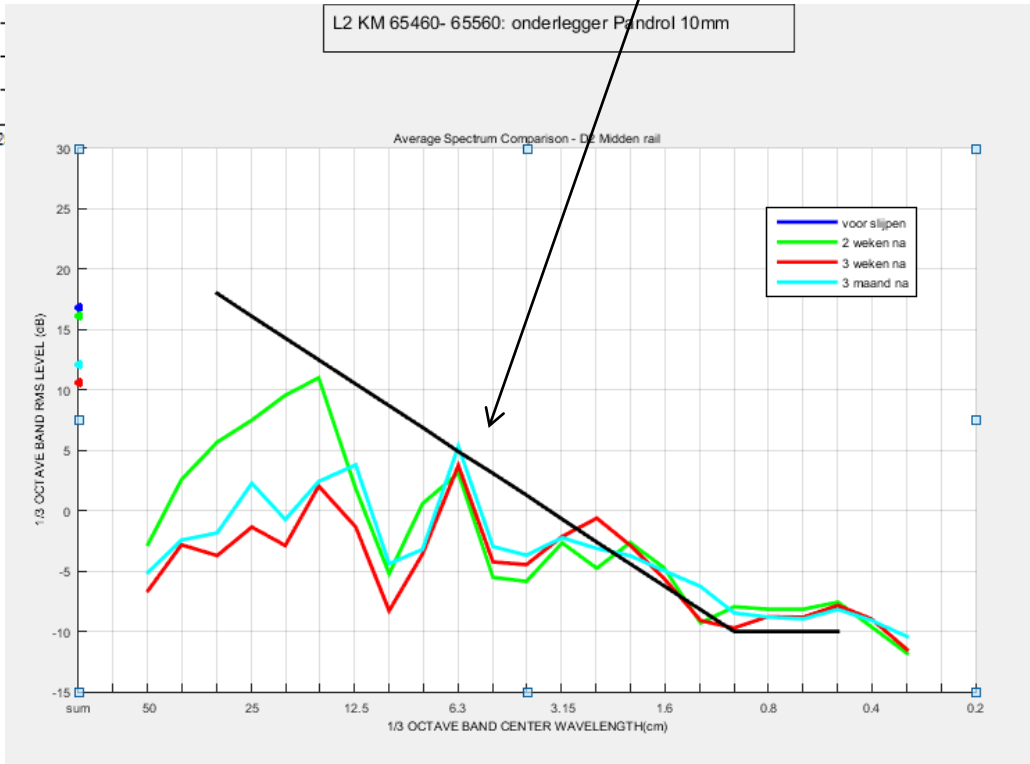


Rail Grinding: Effect higher grinding speed



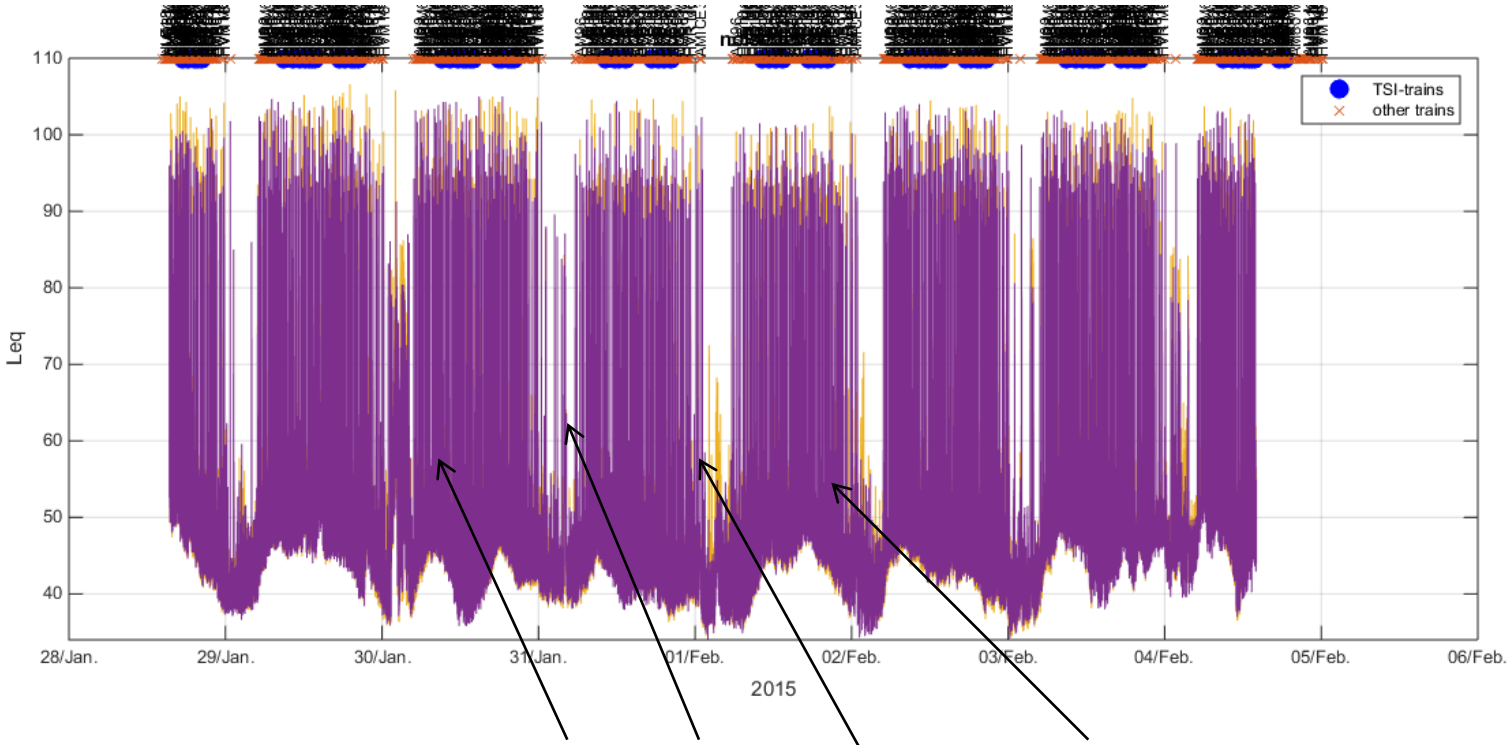
2015: 6cm -> 550Hz -> much better damped

2009: 2.5cm-> 1.2kHz->pinpin mode



Grinding test 01/2015

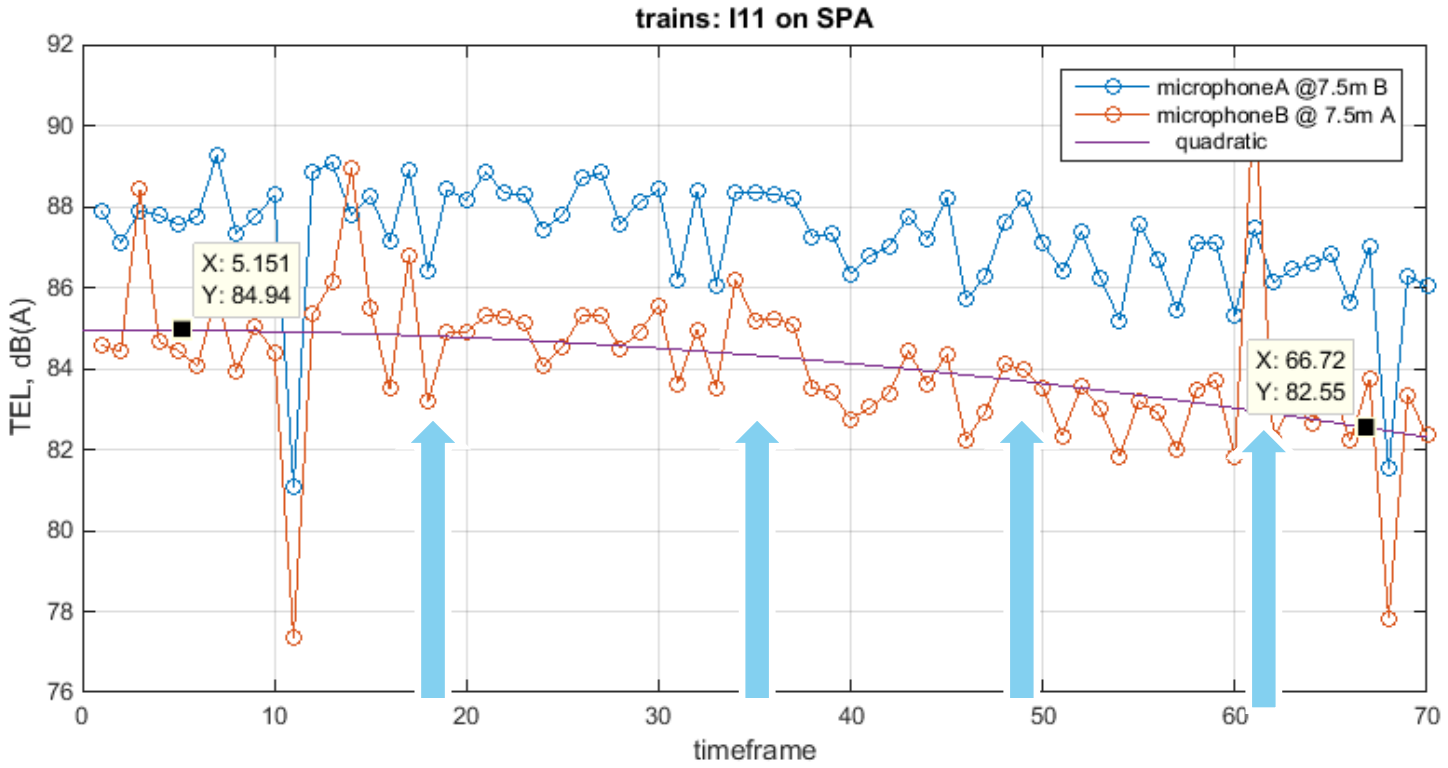
L(A)eq,1s



Before grinding start trackA(1x) (2x) trackB(1x) (2x)

Grinding SPENO RR48 14km/h 2x0.1mm

L50(A) Denderleeuw km22: mixture of rolling stock (33% TSI Noise)



Before grinding start trackA(1x) (2x) trackB(1x) trackB(2x)

1 week

- UIC Class 1-5 +L1-L4: Cyclic grinding
- Renewal sleepers+ railpads

Conclusions

- New INFRABEL railpad design leads to noise reduction of 2.5 to 4 dB with reference to current railpad

- Result achieved by combination of higher damping, dedicated design, and minimum stiffening a factor 2 to 200kN/mm

- Train/track noise monitoring has multiple advantages: maintenance steering, hotspot detection, break block detection, noise mapping info,..

- “Adapted” rail grinding leads to noise reduction of 2.5 dB within the first week after grinding, instead of increase during several months

- No significant budgets needed for applying these measures (expect study, design, research equipment, in situ testing)

- Thanks for your attention!!

VERHELST Ward
ing. - expert
I-AM.23 / Noise & Vibration / s56

Asset Management
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