INTERNATIONAL UNION
OF RAILWAYS

# UIC NOISE DAYS
# DAY 2

## Technical initiatives for reducing Railway Noise

## 9:00 – 9:15 Introduction and Welcome Remarks

***Christian Chavanel UIC***, Rail System Department Director

## 9:15 – 10:30 Round Table

Moderated by ***Christian Chavanel UIC*** Rail System Department Director

- ***Europe's Rail JU. Judit Sandor***, program manager for CCA
- ***TTI Sector. David Villalmanzo***, ADIF, chair of the sector
- ***UIC Noise & Vibration Sector. Jakob Oertli***, SBB, chair of the sector
- ***Infrastructure Sector. Franco Iacobini***, RFI, chair of the sector

## 10:30 – 11:00 Coffee Break

## 11:00 – 11:45 UIC Noise Initiatives

***AERONOISE. Gennaro SICA***, HS2 Aeronoise technical leader

***LOWNOISEPAD. Eduard VERHELST***, SD&M, consultant/General Manager

## 11:45 – 12:30 Acoustic Rail Roughness

***Roughness last findings. Survey results. Dimitros Kostovasilis***, WSP

***Acoustic Rail Roughness Working Group. Emilie FREUD***, SBB

## 12:30 – 12:45 Closing Remarks

***David Villalmanzo***, UIC TTI Sector

## 12:45 – 13:00 Sponsors Booth @ Room Stephenson



#UICRailwayNoiseDays
#MoreTrains

# Christian Chavanel

*UIC Rail System Department Director*

# Round Table

*Moderator*

**Christian Chavanel**

*UIC Rail System Department Director*

**Judit Sandor**

***Europe’s Rail JU**, Program Manager for CAA*

**David Villalmanzo**

*ADIF, **Chair of the TTI Sector***

**Jakob Oertli**

*SBB, Chair of the Noise and Vibration Sector*

**Franco Iacobini**

*RFI, **Chair of the Infrastructure Sector***

# 30’ Coffee Break

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***AERONOISE. Baldrik FAURE***, SNCF Aeronoise expert

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## 12:45 – 13:00 Sponsors Booth @ Room Stephenson

*With thanks to our **Gold sponsor***

SEMPERIT

*Your worldwide partner in customized railway superstructure solutions*

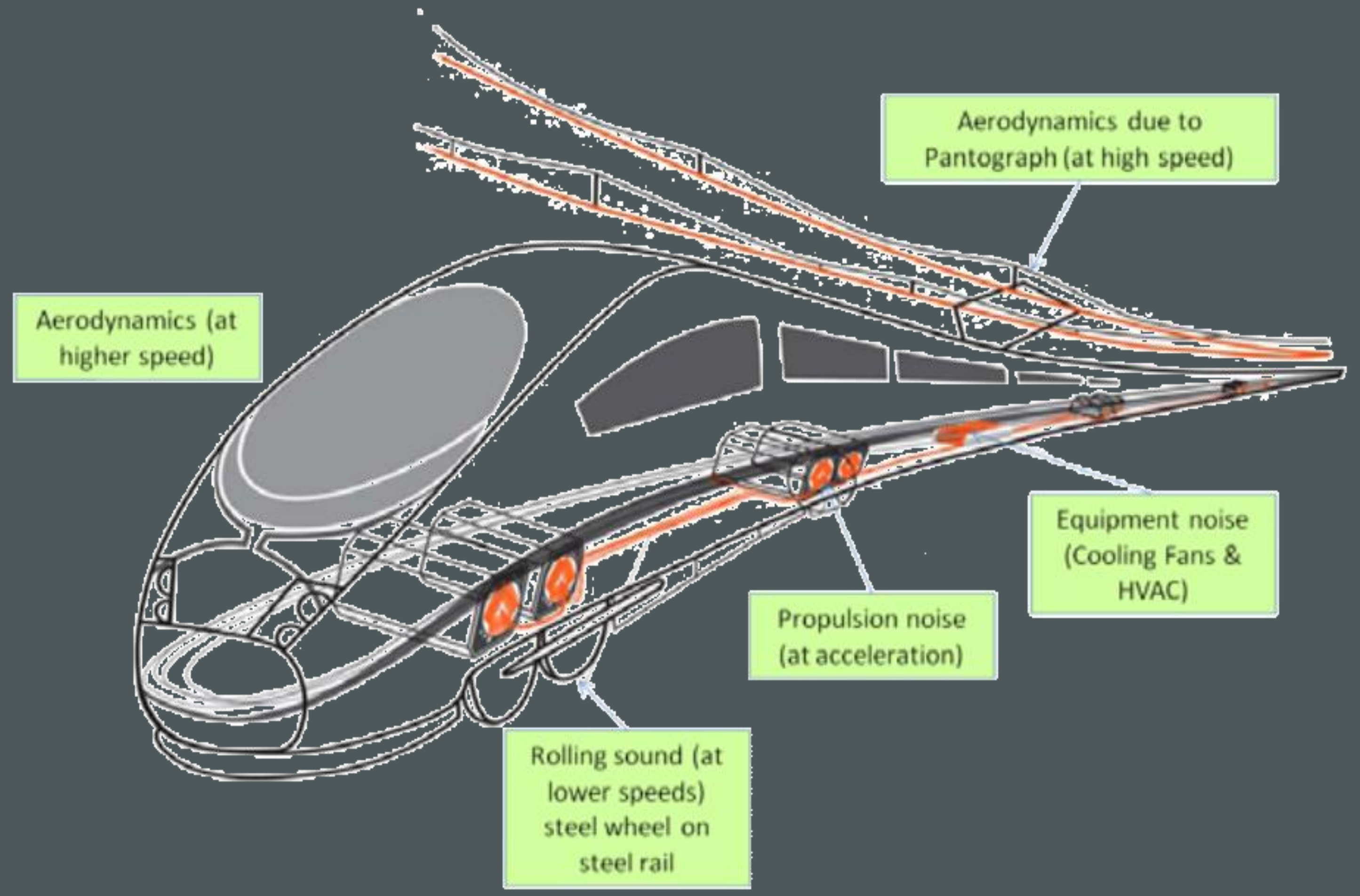
*With thanks to our **Silver sponsor***

Fimor POLYURETHANE

#UICRailwayNoiseDays
#MoreTrains

# UIC Noise Initiatives

# AERONOISE




**Aeronoise Team**

UIC Noise Days, Paris, 01 March 2023

# Content



- What is Aeronoise?
- WP1 Deliverable
- Outcome WP1
- Progress on WP2
  - Approach & Aims
  - Metrics
  - Optimization Measurement Set Up
  - Rolling Noise Estimation
- Next Steps

# What is Aeronoise?

- Aeronoise is a UIC project which aims to **develop a measurement and analysis protocol for the characterisation of aerodynamic sources of high speed train**
- Participants: ADIF, BANENOR, HS2, SNCF, SZ & TRAFIKVERKET
  - Started in February 2020 (but delayed by the Pandemic)
- Organised in 3 WPs
  - WP1 – Benchmark
  - WP2 – Definition of Protocol & Analysis
  - WP3 – Demonstrator
- Technical Partners WP1&WP2: SENER + ISVR Consulting
- Deliver a new IRS: Measurement and analysis systems to characterise the aerodynamic noise of HS trains
- Opportunity to improve ISO/CEN activities, TSI, Noise prediction methods for High Speed Traffic

# WP1 Deliverable

The deliverable includes

- Description of source mechanisms
- Description of mitigation
  - Train
  - Track
  - Noise Barrier
- Rating of aeroacoustic sources based on array measurements
- Benchmark
  - Regulations
  - Measurements and Analysis

Download deliverable **for free** at: https://www.shop-etf.com/en/aeronoise-measurement-and-analysis-systems-to-characterise-the-aerodynamic-noise-of-high-speed-trains-technical-report-benchmark-studies

# Outcome WP1 – Benchmark Regulations



Differences in existing regulations

- Train Speed
- Noise indicator
- Measurement location

➔ No assessment of the type of source or source location

| For Moving Trains | | Applicable Rolling Stock | Metric | Train Speed (km/h) | Maximum Allowable Sound Pressure, dB(A) | Measurement Location | |
|---|---|---|---|---|---|---|---|
| Location | Reference | | | | | Elevation (m) | Distance from centerline (m) |
| **US** | 40 CFR 201.12 | Locomotive | $L_{max}$ (fast) | All | 90 | 1.2 (top of rail) | 30 |
| | 40 CFR 201.13 | Rail Cars | $L_{max}$ (fast) | >45 | 93 | | |
| **EU & UK** | TSI Noise 2014 NTNS NOI 2021 | Locomotive | $L_{pAeq,Tp}$ | 80 – 250 | 84 - 99 | 1.2 (top of rail) | 7.5 |
| | | EMUs | | 80 – 250 | 80 – 95 | | |
| | | DMUs | | 80 – 250 | 81 - 96 | | |
| **China** | GB 12525-90 | All Rolling Stock | $L_d$ | all | 70 | 1.2 (top of rail) | 30 |
| | | | $L_n$ | | 60 | | |
| **Japan** | Environmental Law 91 of 1993 | High Speed Rail | $L_{pASmax}$ | all | 75* | 1.2 (above ground) | 25 |
| | | General Rail | $L_d$ | all | 60* | | 12.5 |
| | | | $L_n$ | | 55* | | |

***Sound pressure level at receiver allows use of barrier and other noise path attenuation methods**

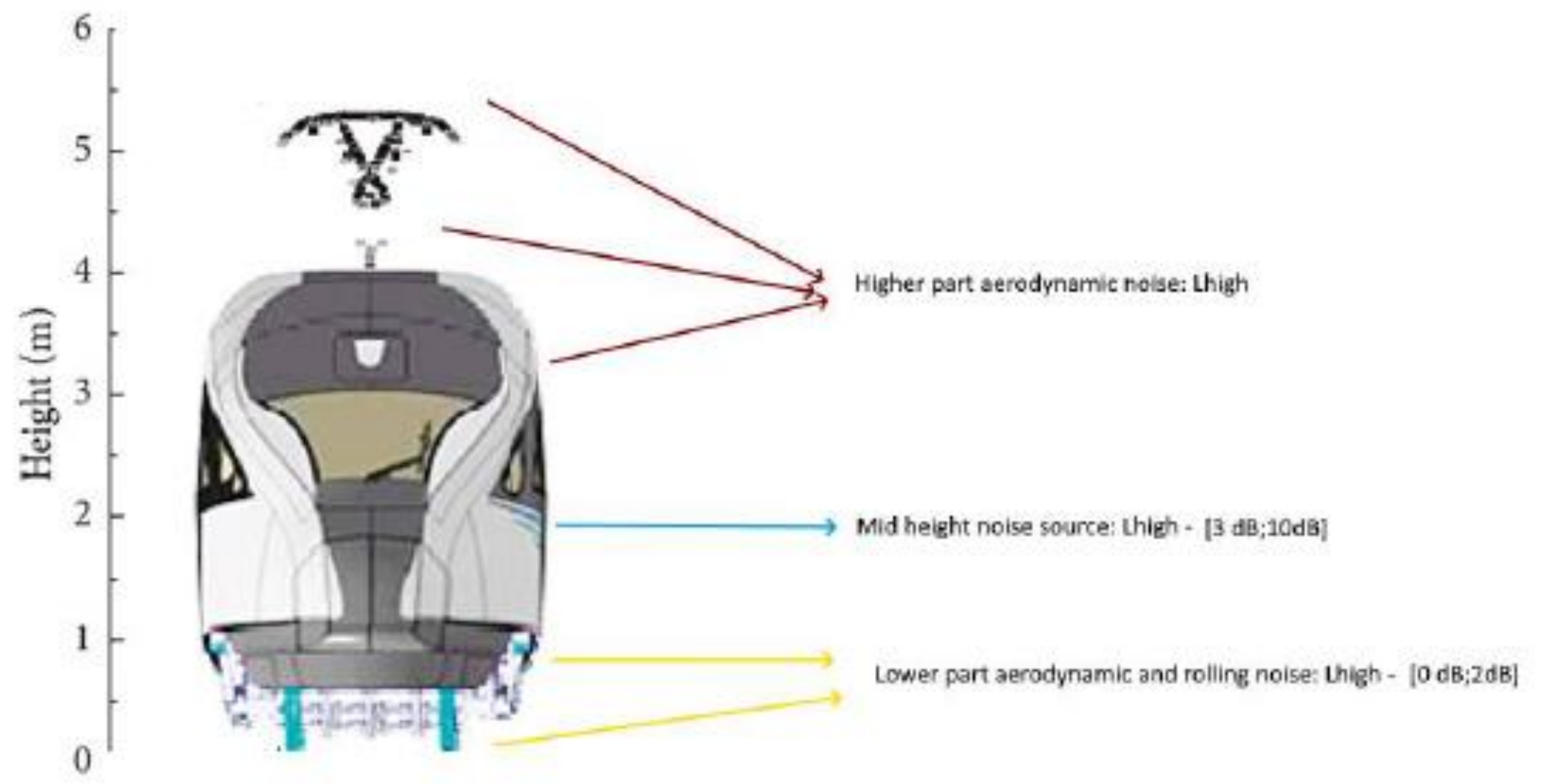
# Outcome WP1
# Benchmark Measurement Protocol



## Rating existing measurements & analysis protocols

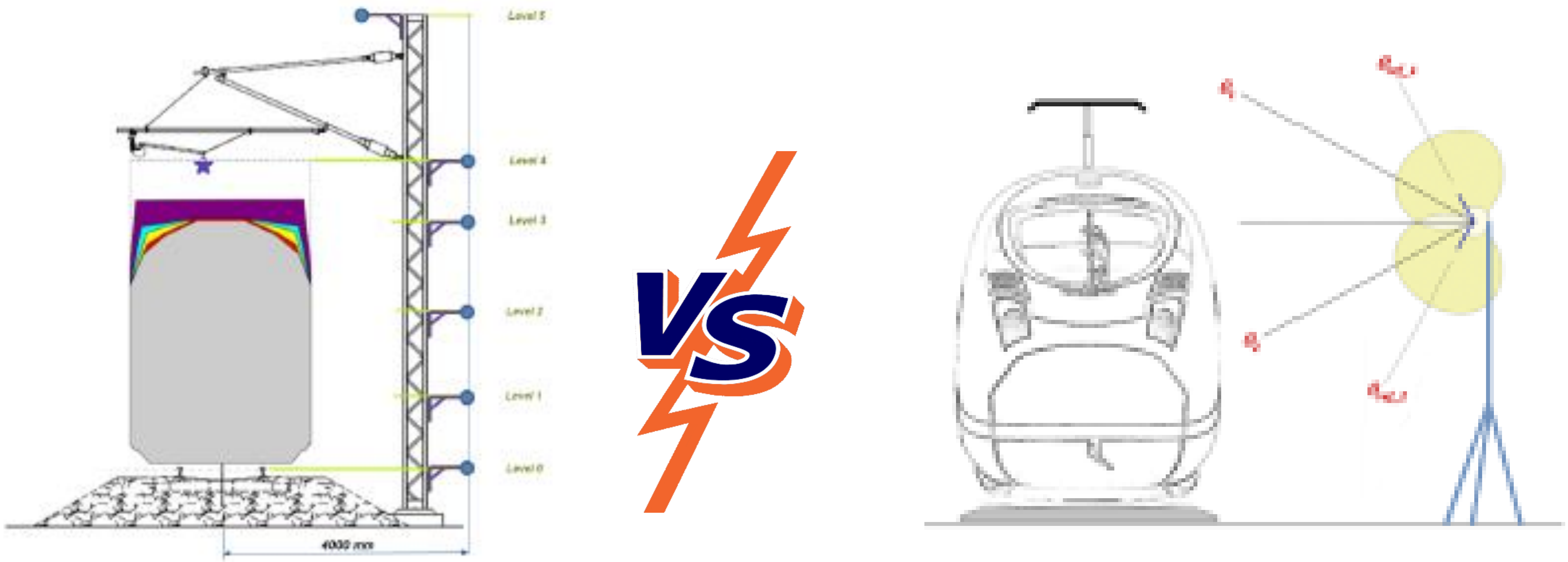
| Evaluation metrics for AERONOISE | ISO 3095:2013 | MICROPHONE ARRAYS | HS2/SENER LAS INVIERNAS | INTENSITY / PU PROBES | HYBRID TEST-SIMULATION | ATPA, PBA, VTN & TWINS (AS UNIQUE TOOL) |
|---|---|---|---|---|---|---|
| General applicability of method | | | | | | NOT APPLICABLE TO AERONOISE PROJECT AS A UNIQUE TOOL |
| Simplicity in execution and post-process | | | | | | |
| Use of conventional, proven sensors | | | | | | |
| Accuracy of results | | | | | | |
| Dependency on copyright protected resources | | | | | | |
| Feasibility as add-on to ISO 3095 | NOT APPLICABLE | | | | | |
| Total cost | | | | | | |

HS2/Sener already fulfils most of the Aeronoise requirements



# Outcome WP1 – Protocol Recommendations






| Evaluation metrics for AERONOISE | CATENARY POLE with standard MIC & hybrid prediction/measurement approach | CATENARY POLE with single TRIPLETS & hybrid prediction/measurement approach | CATENARY POLE with multiple TRIPLETS & hybrid prediction/measurement approach |
|---|---|---|---|
| General applicability of method | | | |
| Simplicity in execution and post-process | | | |
| Use of conventional, proven sensors | | | |
| Accuracy of results | | | |
| Dependency on copyright protected resources | | | |
| Feasibility as add-on to ISO 3095 | | | |
| Total cost | | | |

Main recommendations

- Catenary pole for measuring aerodynamic noise
- Numercial/experimental hybrid method to separate rolling noise from aerodynamic noise
- Triplets of microphones are an interesting approach but requires more work. Initial findings presented at IWRN

35

*Submission No. 37*

**Use of heterogeneous microphone triplets for simplified noise apportionment in pass-by measurements**

Jaume Solé[1], Pierre Huguenet[1], Mercedes Gutierrez Ferrandiz[2]

[1]SENER Ingeniería y Sistemas, Noise and Vibration Technical Office, C/. Creu Casas i Sicart 86-88, Cerdanyola del Valles, 08290 Barcelona, Spain
[2]UIC INTERNATIONAL UNION OF RAILWAYS, Head of Asset Management, Infrastructure and Interfaces with Rolling Stock, 16 rue Jean Rey – 75015 Paris

# Work Package 2



Objective:

Define a measurement and analysis protocol for the characterisation of aerodynamic noise sources

Key elements of the protocol:

- General approach
- Noise indicators
- Measurement setup
- Data processing
  (Rolling Noise Separation using Hybrid Method)


WP2 Kick off Meeting 06/22

# Work Package 2 – Approach & Aims



Approach similar to N&V assessment manual of the Federal Transit Administration of the USA:

- General assessment - based on a few positions in catenary pole + references at 7.5m / 25m
- Detailed assessment - include more positions, accelerometers, optical sensors, etc

Measurement Set Up

- Adaptable to any catenary pole
- Minimum operational disruption

➔ **Define "train classes" with respect to noise emissions as with dwellings or noise barriers?**

**Sound absorption versus sound insulation**

| Absorption groups | Sound absorption coefficient | Insulation group | Sound insulation coefficient |
|---|---|---|---|
| A1 | up to 4dB | B1 | < 15dB |
| A2 | 4-7dB | B2 | 15-24dB |
| A3 | 8-11dB | B3 | 25-34dB |
| A4 | 12-15dB | B4 | > 34dB |
| A5 | > 15dB | | |

# Work Package 2 – Metrics

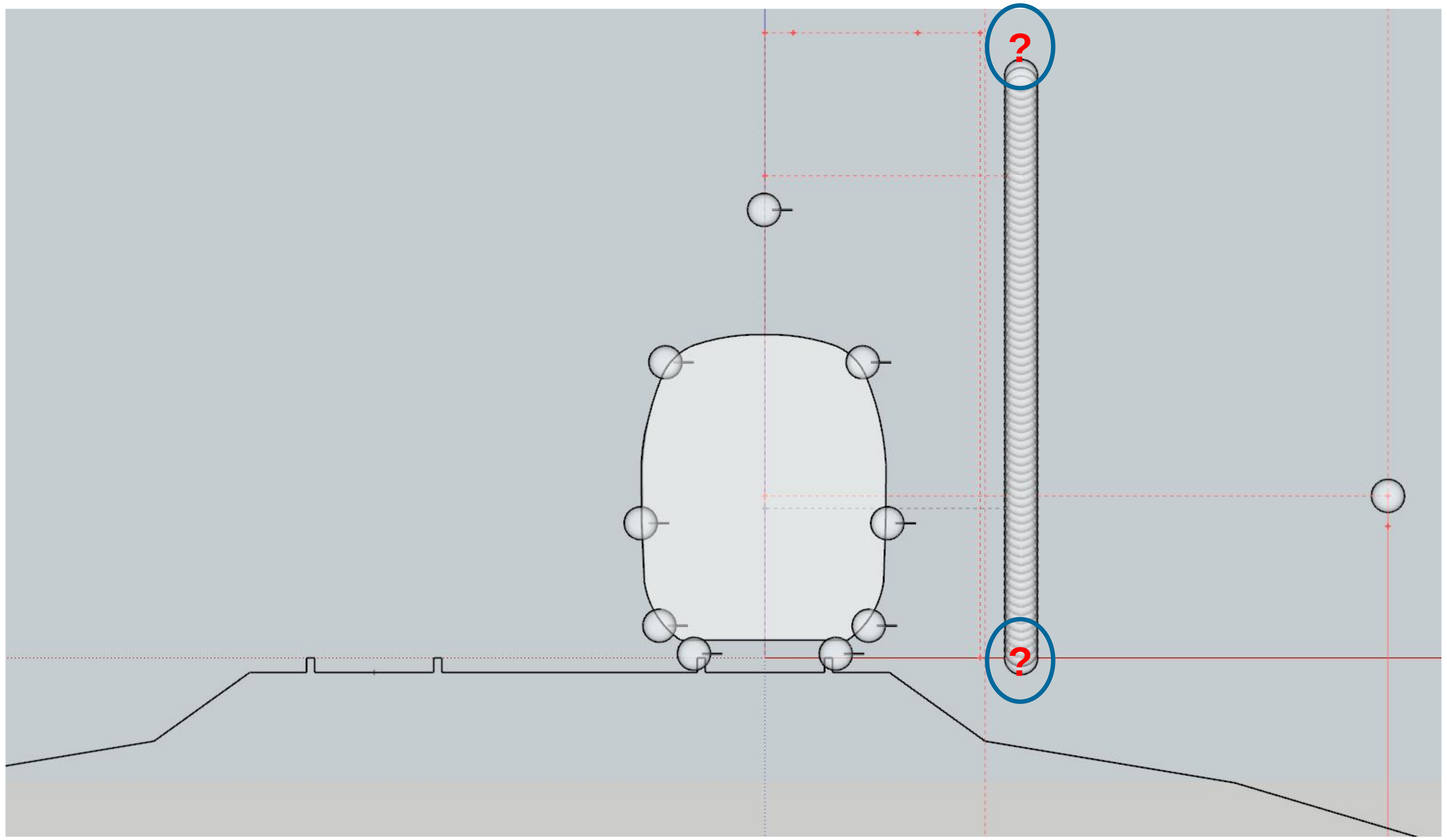


- Use common metrics
  - Focus at least on $L_{A,eq,Tp}$ (pass-by)
  - $L_{max}$
- Different metrics depending on the test grade
  - Global linear sound power for general assessment,
  - Sound power + $L_{max}$ + spectral data for detailed assessment.
- Metrics for additional microphones still in development

# Work Package 2 – Test set up

Test setup investigated through modelling and optimisation algorithm for the identification of optimal distance between track and catenary pole and number of sensors.

- A minimum of 5 microphones through the catenary pole are needed for separation
- It is not possible to achieve separation between rolling noise and low aerodynamic noise through microphones only
- Consideration of additional sensors or modelling to support separation



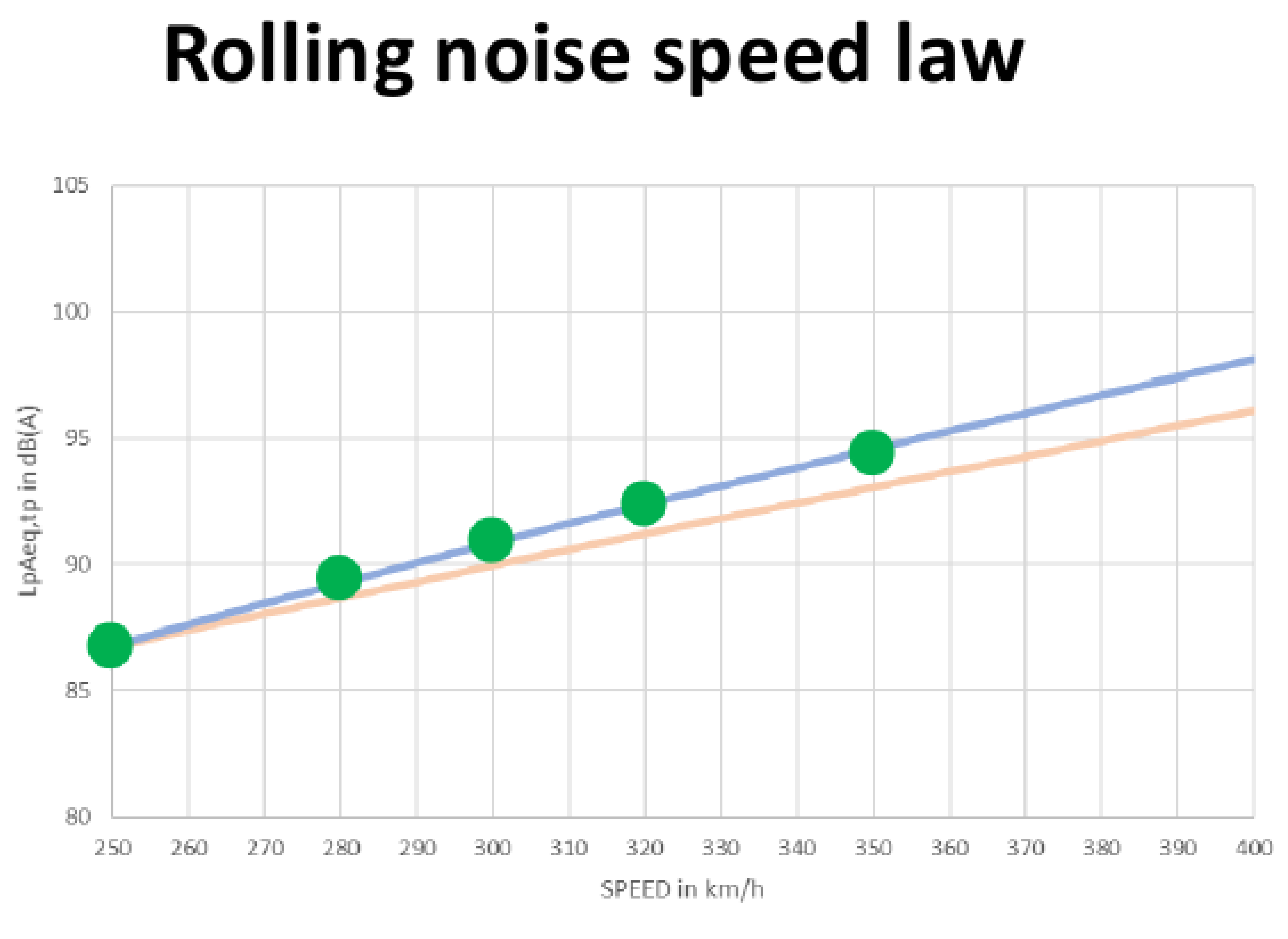

**Due to the positions of the noise sources and geometry of the train, acoustic effects need to be considered: screening, horizontal and vertical diffraction, specific absorption of ballast, diffusion coefficient, reflection number, etc.**

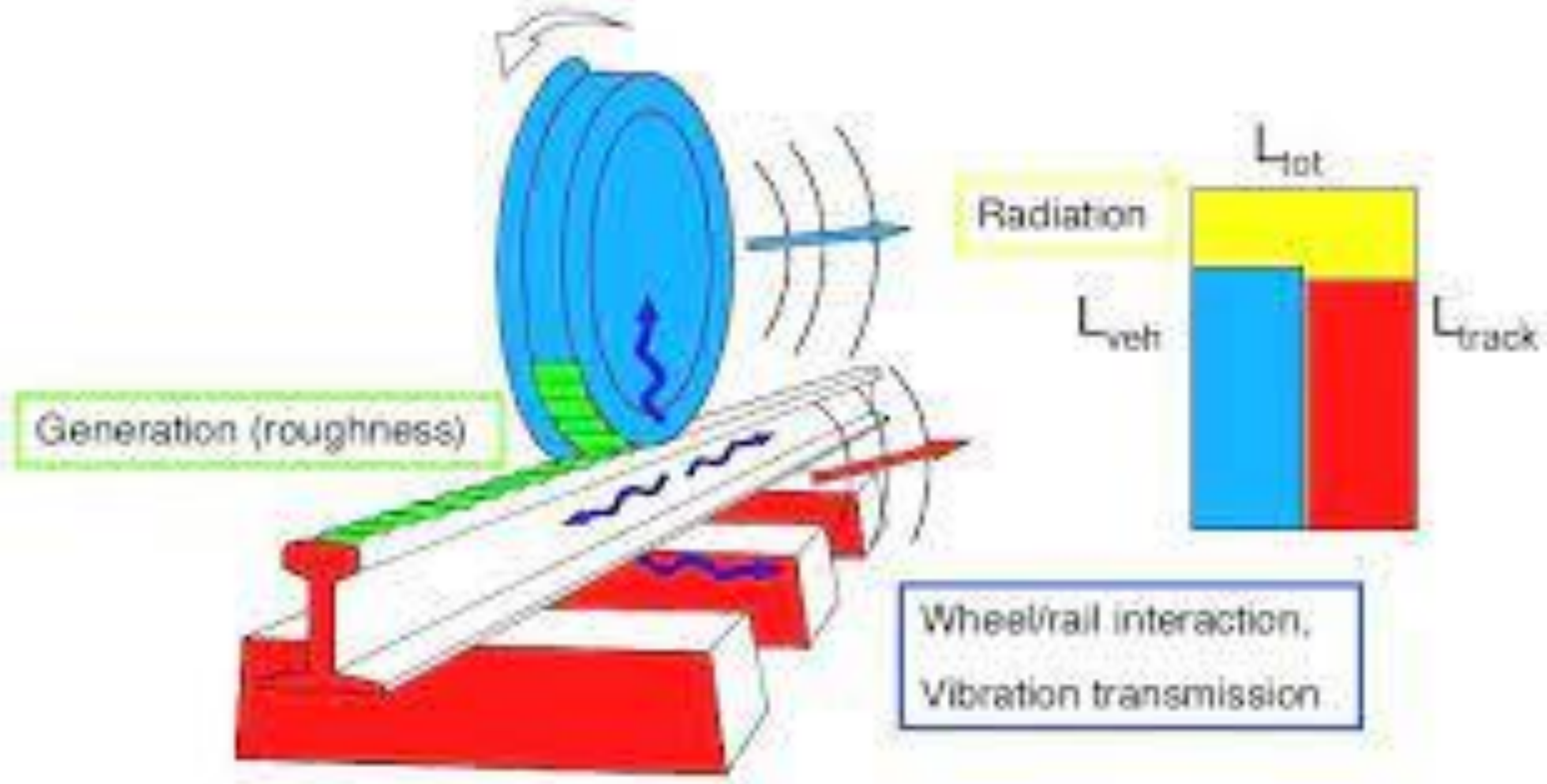
**A specific ODEON model was created with a given train geometry and track. 5 linear noise sources were introduced as initial approach. Line of receivers on a specific vertical pole, separated by 10 cm, were introduced to compute the relationship between noise sources and near-field values.**

# Work Package 2 – Hybrid Method

Rolling noise identification is important for source separation

- General Assessment
  - Extrapolation rolling noise using 30log(V) equation from lower speeds pass by measurements
- Detailed Assessment
  - Compatibility with the current state of the art
    - TWINS Based Methods
    - PBA Approach
  - Aeronoise is also working on a novel rolling noise separation method (Roughness based method)



# Next steps



- WP2 Report under review

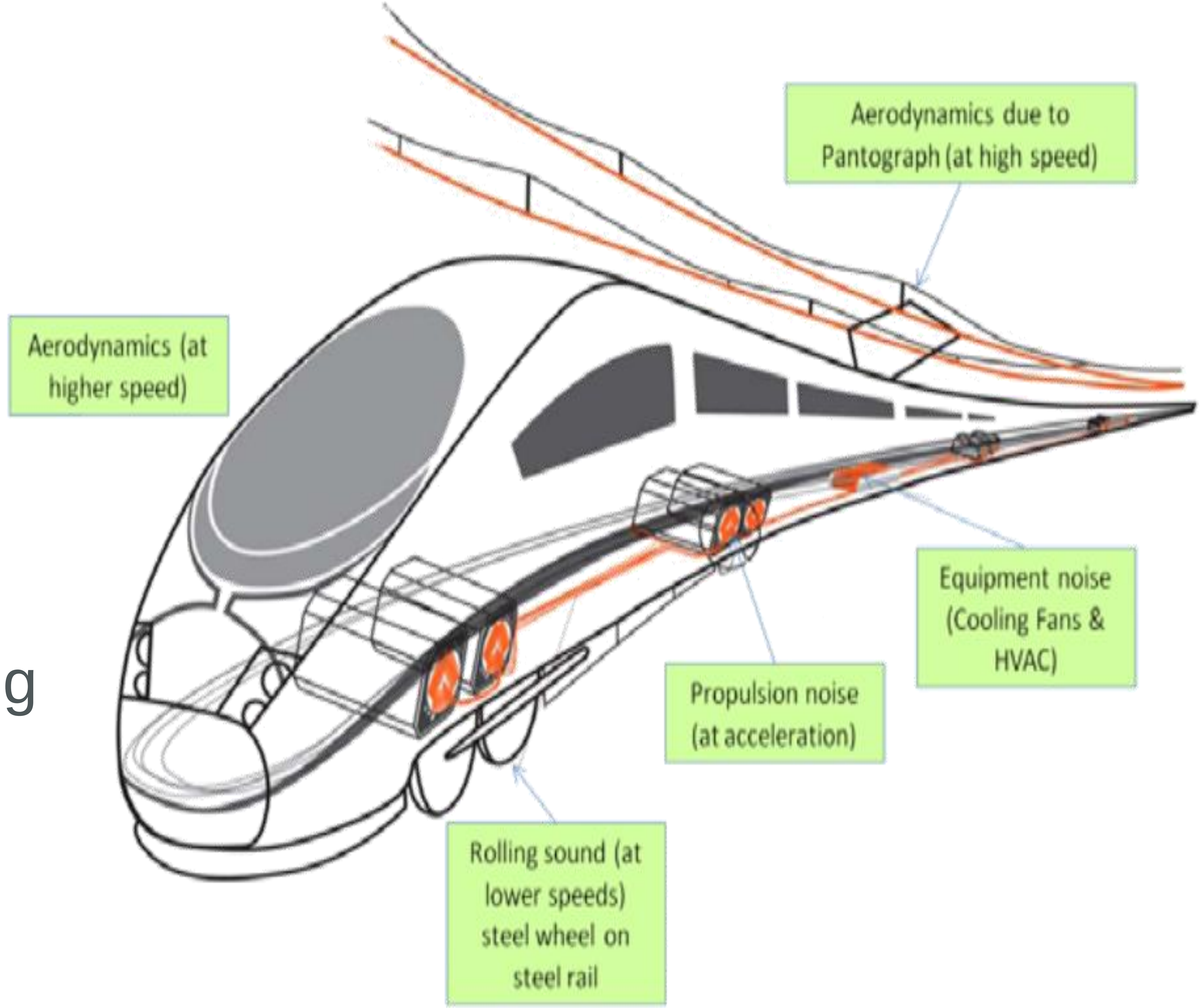
➔ To be completed by April 2023

- Preparation of WP3 Tender Documentation

➔ **WP3 Tender Launch by May 2023**

- Identification of infrastructure and rolling stock for experimental validation

- WP3 expected to be completed Beginning 2024 (subject to measurements)



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**Stay in touch with UIC:**

**www.uic.org**

**#UICrail**

**Thank you for your attention.**

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lownoisepad

# LOW-COST NOISE CONTROL BY OPTIMISED RAIL PAD

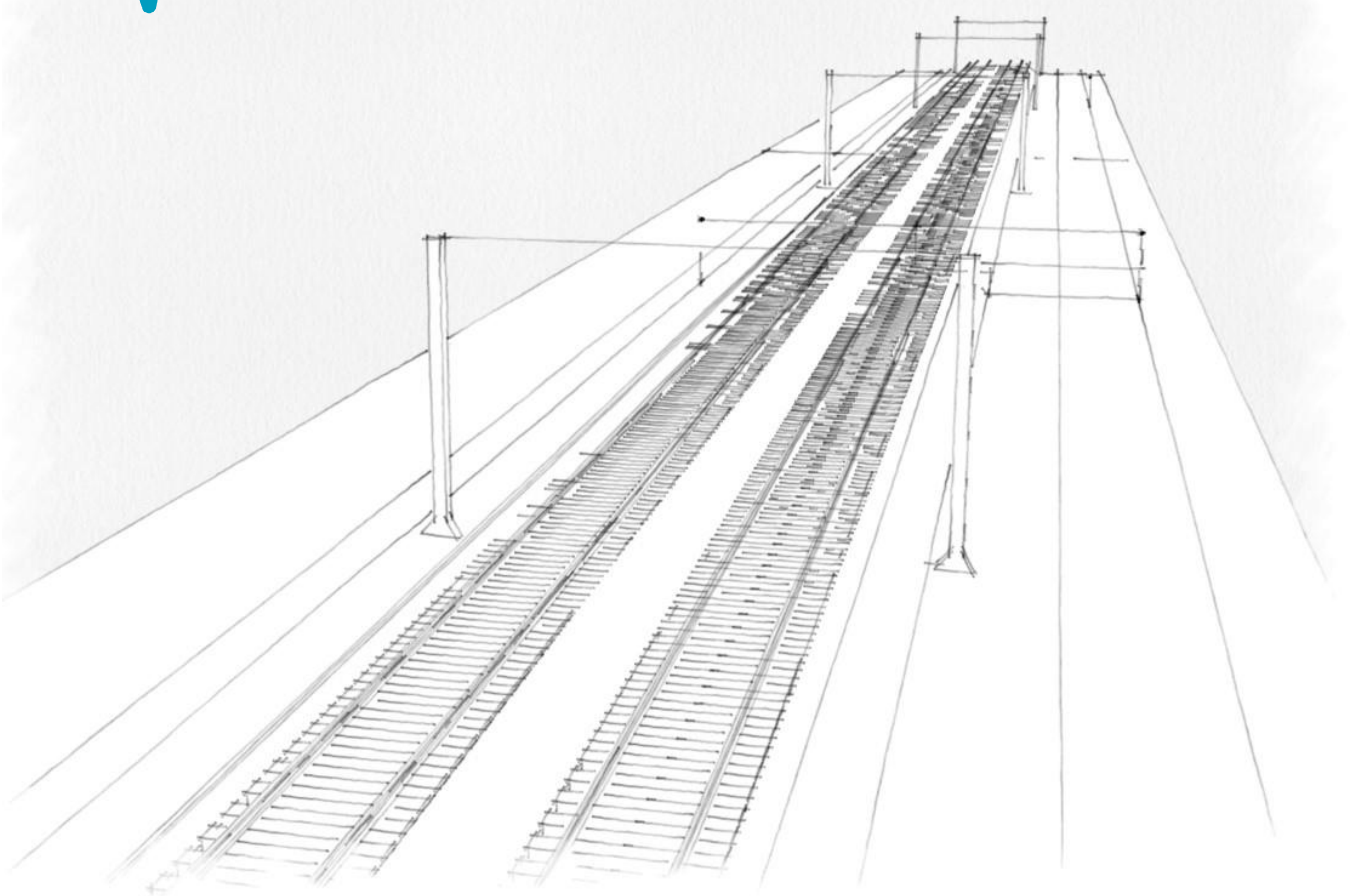
**Eduard Verhelst**
SD&M Structural Dynamics & Monitoring

March,1 2023

# Content

- How LOWNOISEPAD was created
- Goal
- Project members
- Some statistics
- Planning
- Applied methodologies (WP3,WP5,WP6)
- Test site selection (WP4)
- Measurements (WP5)
- Software Tool (WP6)
- Results (WP6)
- Conclusions

lownoisepad



# How was created

Potential for Railpad optimisation was investigated in detail at INFRABEL in 2013 after comparing noise emission on several rail pads within the same stiffness range but different contact surface with the rail, resulting in completely different TDR and Noise emission

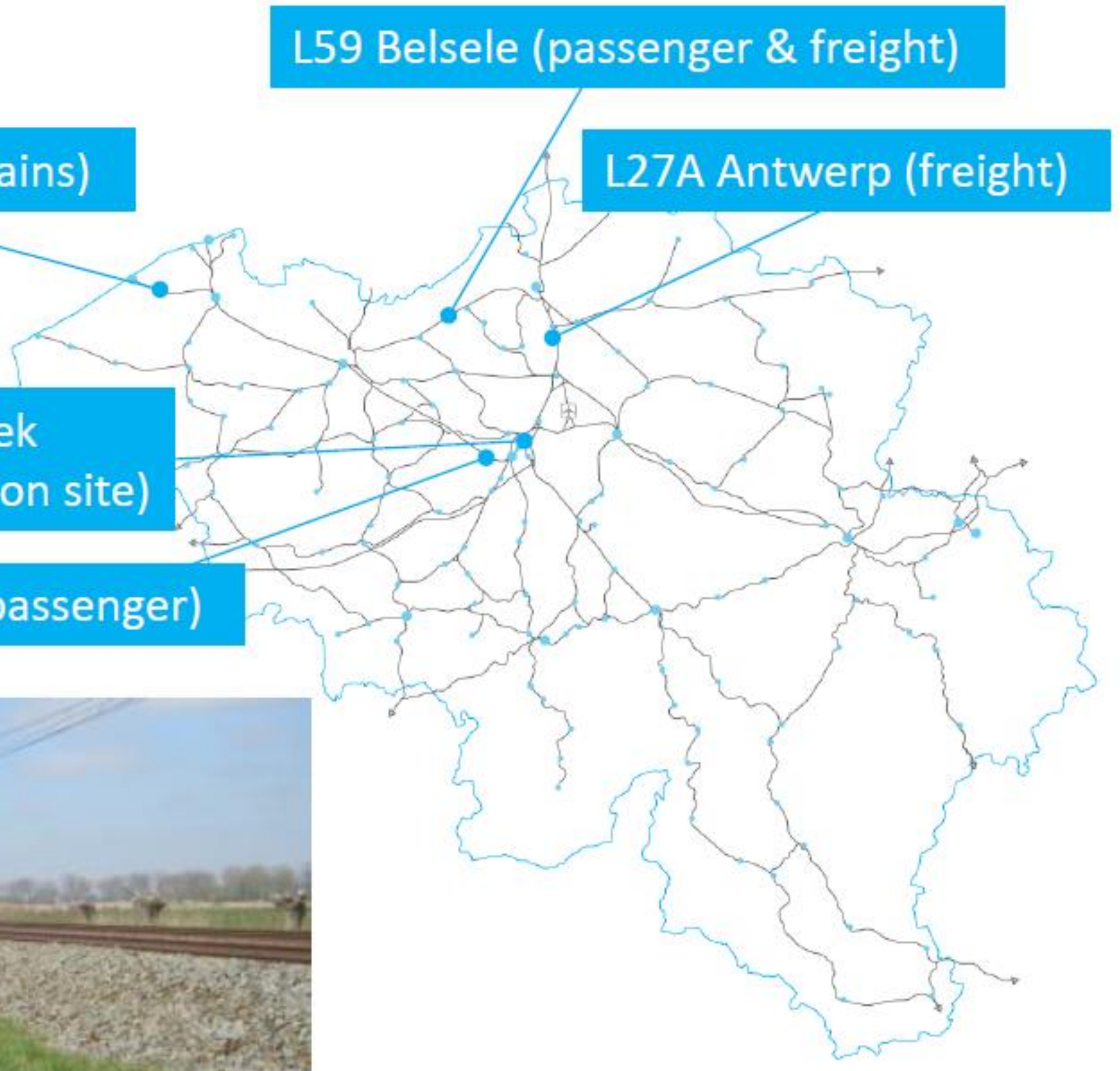
UIC Noise and Vibration Sector Round Table discussions in 2014

UIC Opt-In Process (2020)

Kick-off the LOWNOISEPAD project (2021-2022)

UIC Railway Noise Days **28 February 2023**

**Test Location at INFRABEL 2013-2017**




# Goal of LOWNOISEPAD



To be PRAGMATIC, solution-based on results of the terrain

No computer-based calculation but validation, validation, validation by measurements (including training to perform measurements)

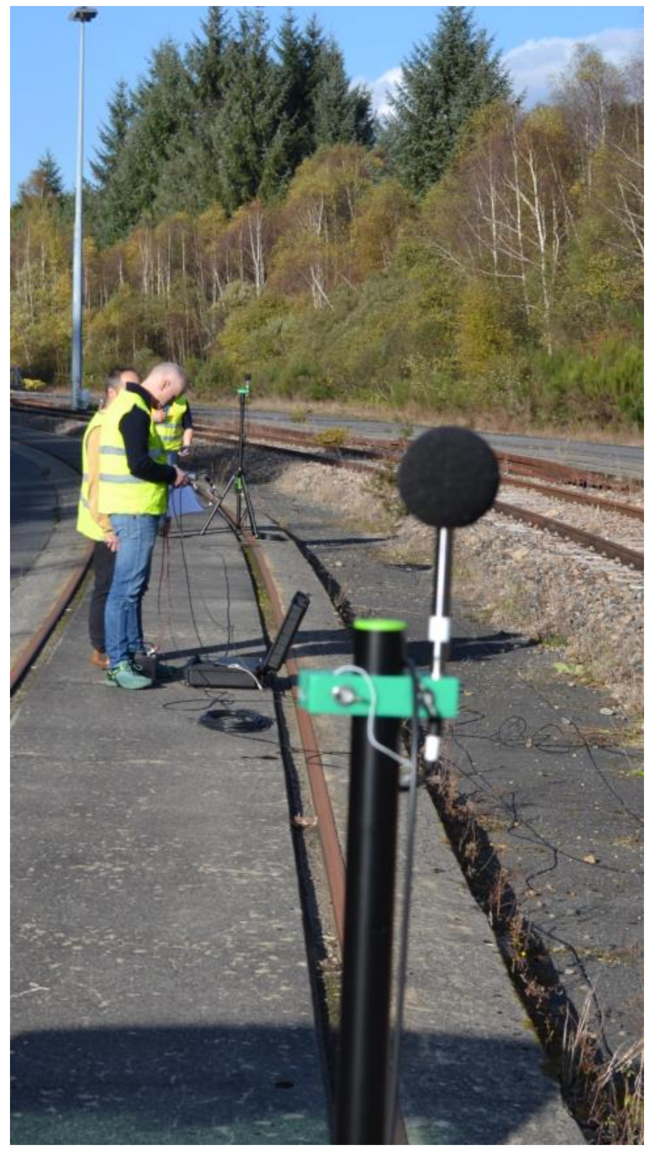
Same measurement set-up approach and data processing for all Project Partners

Access to a wide variation of rolling stock, speeds, rail fastener systems (12 Infra managers) to assess rail pad change on noise emission

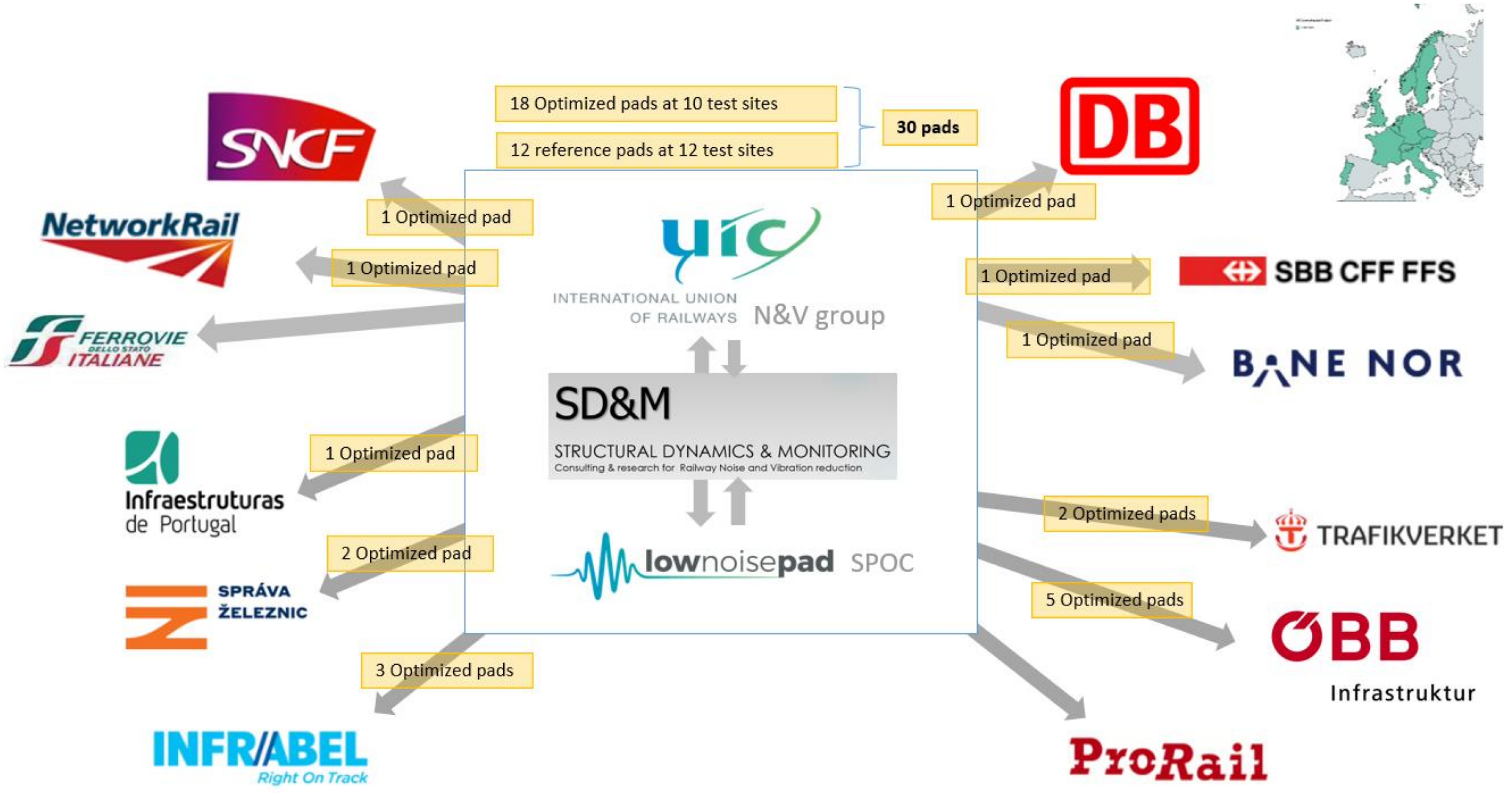
Not only Acoustical engineers but also Track engineering is involved (networking inside the companies)

Close collaboration with the UIC Train Track Interaction Sector

**Training site, not a test site!**



# 12 European Railway Infrastructure Managers



# Some statistics



**Test sites in 12 countries, at the end of the project:**

**A total of 30 pads to be compared**

- ✓ 18 optimized pads at 10 test sites
- ✓ 12 reference pads at 12 test sites

**Today data available from 8 countries**

- ✓ Wait for data from final 4 countries
- ✓ 3 optimized pads
- ✓ 4 reference pads

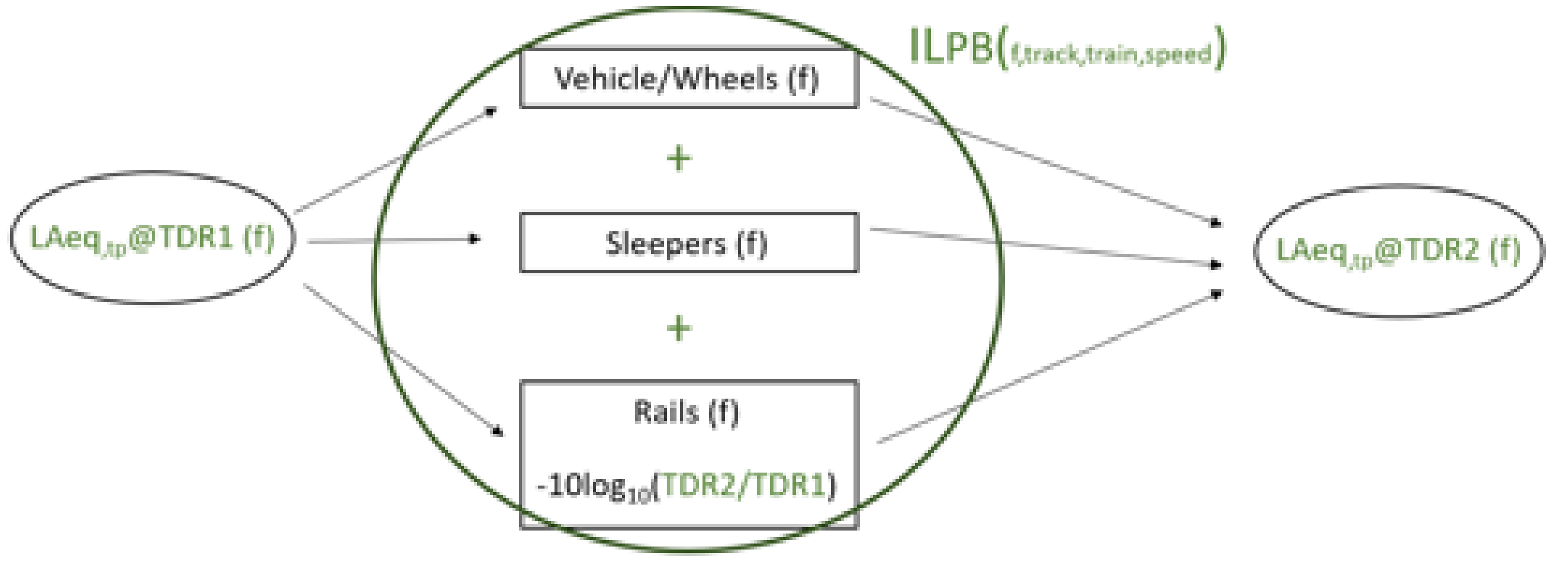
**Optimized pads installed from 4 different suppliers:**

- ✓ Semperit, Vossloh, Calenberg, Getzner,…
- ✓ Goal: High TDR, as low as possible stiffness
- ✓ All approved by, and customized design for project partners
- ✓ Various Railpad stiffnesses kSP: 60 – 230 kN/mm
  - ✓ Frequency dependent stiffness and damping
  - ✓ Some have FEM optimized design for high damping of rail resonances

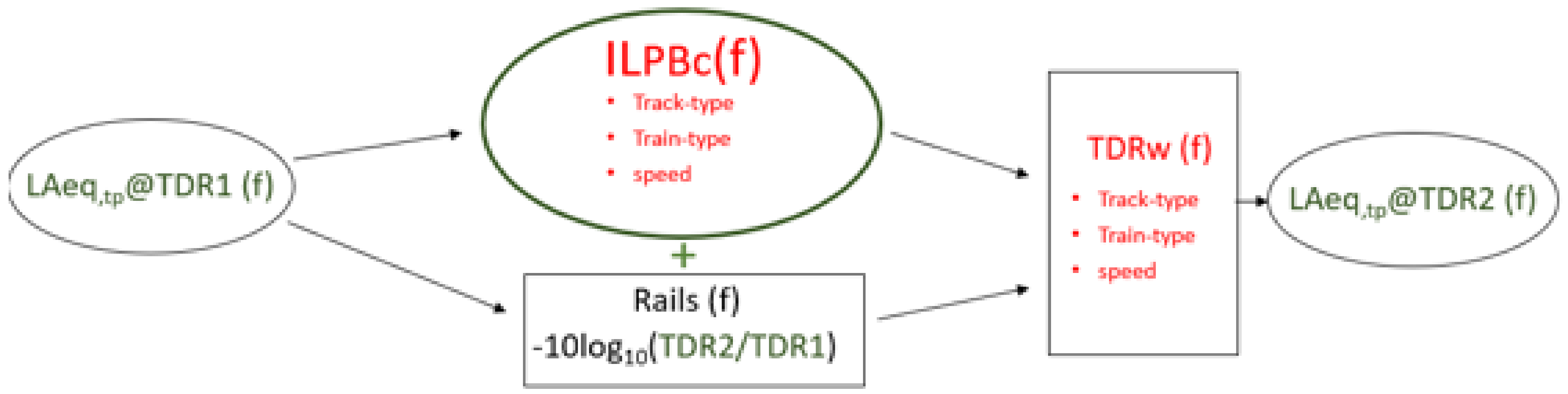
# LOWNOISEPAD planning

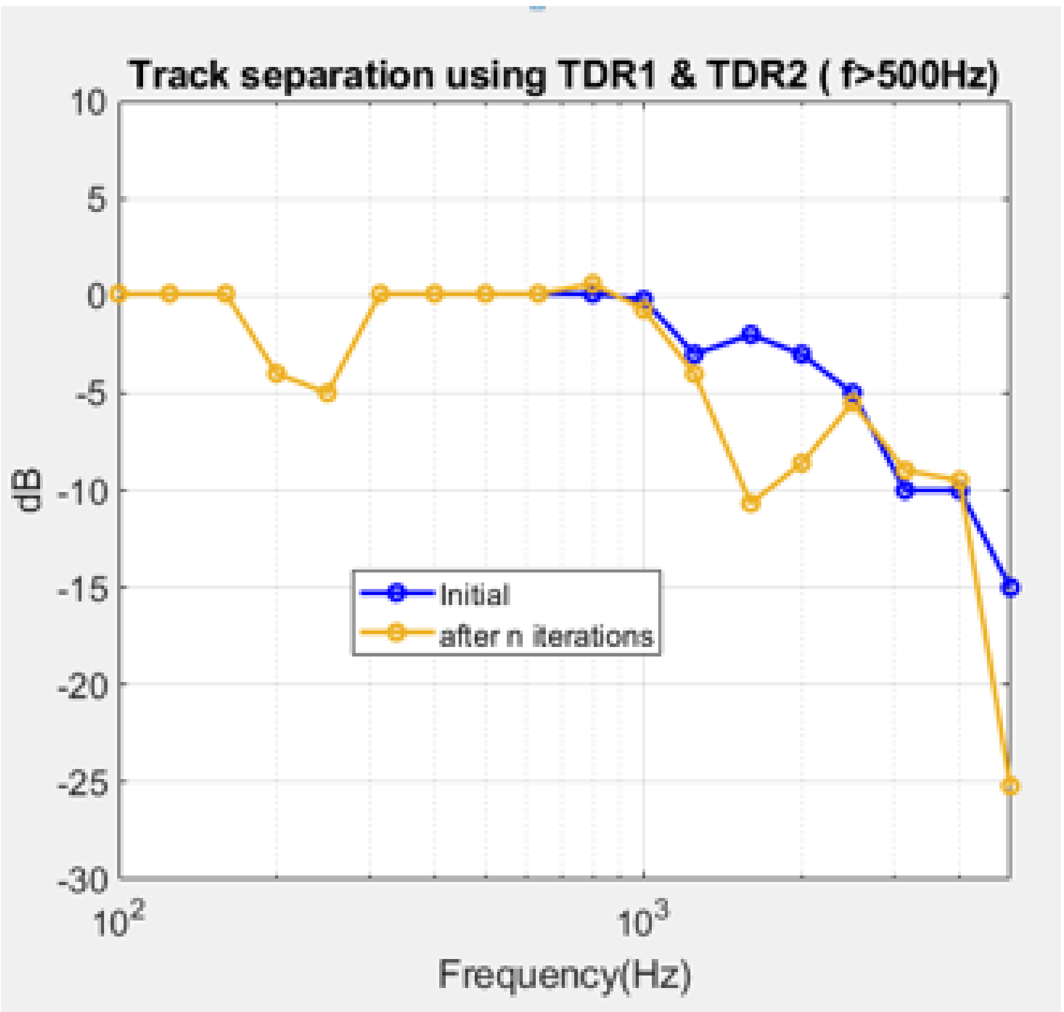
| Updated planning | M-2 02/2021 | M-1 03/2021 | M1 04/2021 | M2 05/2021 | M3 06/2021 | M4 07/2021 | M5 08/2021 | M6 09/2021 | M7 10/2021 | M8 11/2021 | M9 12/2021 | M10 01/2022 | M11 02/2022 | M12 03/2022 | M13 04/2022 | M14 05/2022 | M15 06/2022 | M16 07/2022 | M17 08/2022 | M18 09/2022 | M19 10/2022 | M20 11/2022 | M21 12/2022 | M22 01/2023 | M23 02/2023 | M24 03/2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WP0: Preparational meetings (One2One) | UIC | UIC | | | | | | | | | | | | | | | | | | | | | | | | |
| WP1: Roadbook: procedures for all WP | | | UIC | UIC | | | | | | | | | | | | | | | | | | | | | | |
| WP2: Track database | | | IM | IM | IM | | | | | | | | | | | | | | | | | | | | | |
| WP3: Select railpads to be tested, and/or | | | | | IM | IM | IM | | | | | | | | | | | | | | | | | | | |
| WP3: Railpad optimalisation | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WP4: Site selection | | | | | | | IM | IM | | | | | | | | | | | | | | | | | | |
| WP4: Railpad installation | | | | | | | | IM | IM | IM | IM | IM | IM | | | | | | | | | | | | | |
| WP5: Measurements -> dBase | | | | | | | | | | IM | IM | IM | IM | IM | IM | IM | IM | IM | IM | IM | | | | | | |
| WP2->5: support by SD&M | UIC / SD&M (>70 one2one and > 10 with all SPOC teams meetings) | | | | | | | | | | | | | | | | | | | | | | | | | |
| WP6: dissemination, data analysis & Software tool | UIC / SD&M | | | | | | | | | | | | | | | | | | | | | | | | | |

# Applied methodologies




- ✓ WP2: Track database as a start: what is available
- ✓ WP6: TDR Single value parameter:
  - Based on TDR sum in specific frequency range
  - Taken into account the A weighting and ISO 3095 limit
- ✓ WP3 and WP6: Software tool (under construction)
  - Railpad selection and TD influence
  - Iterate Track contribution from measured Lp at 2 sites




Lp,measured1 @ TDR1 ; Lp= $LAeq_{,tp}$ (f) ; 100Hz<f<5kHz

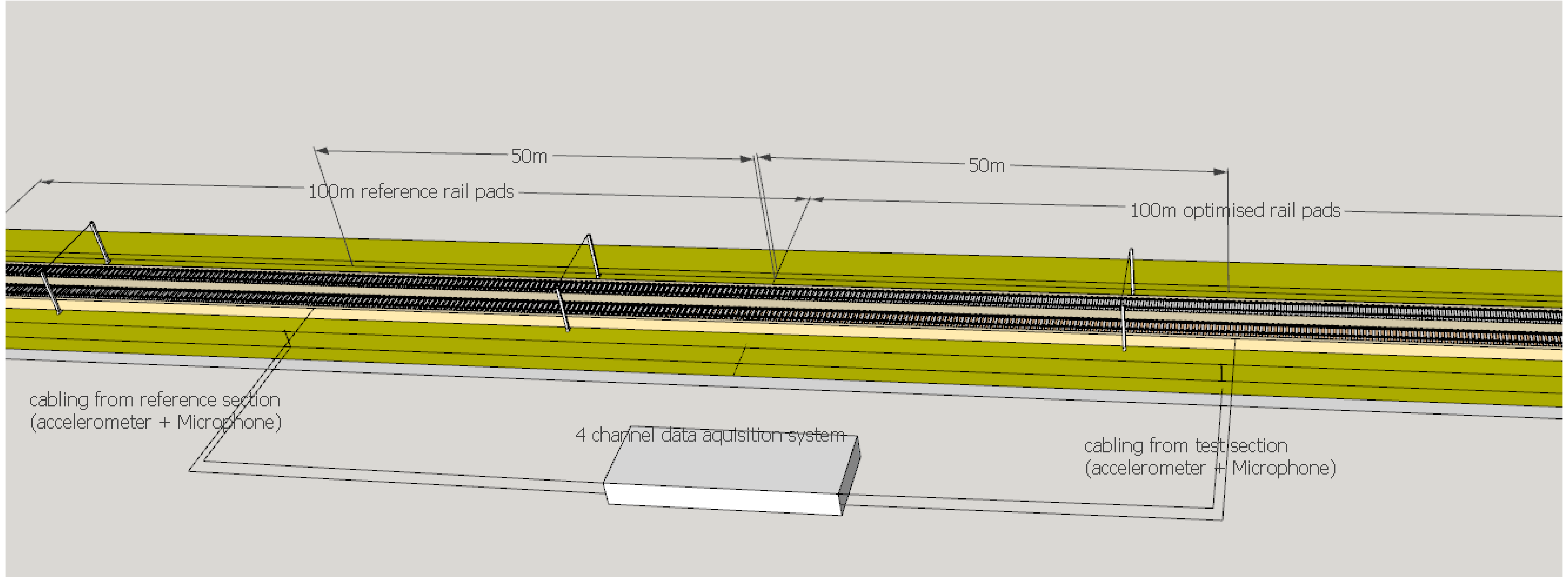
Lp,measured2 @ TDR2

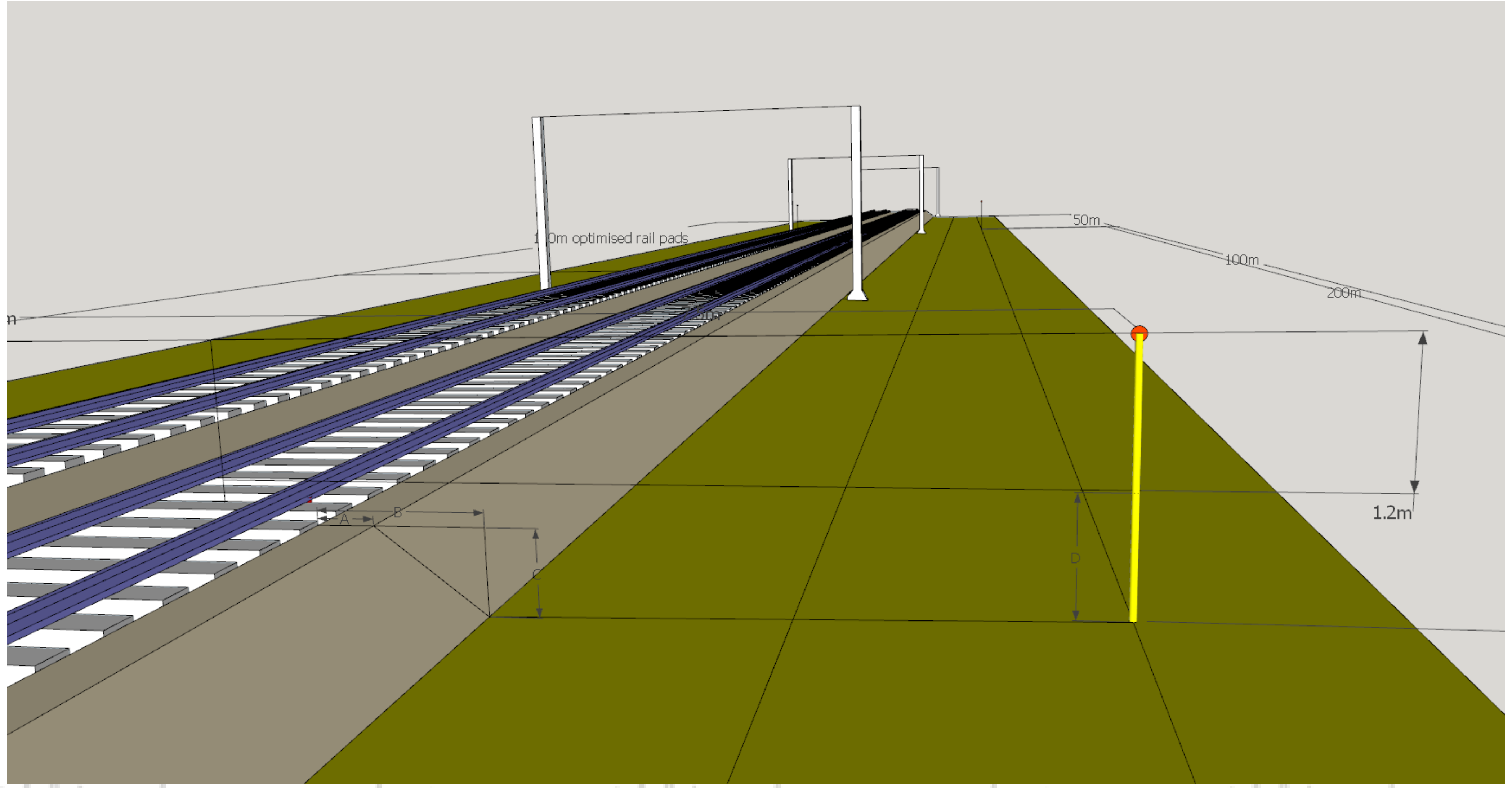
Lp,estimated2n@TDR2n ??

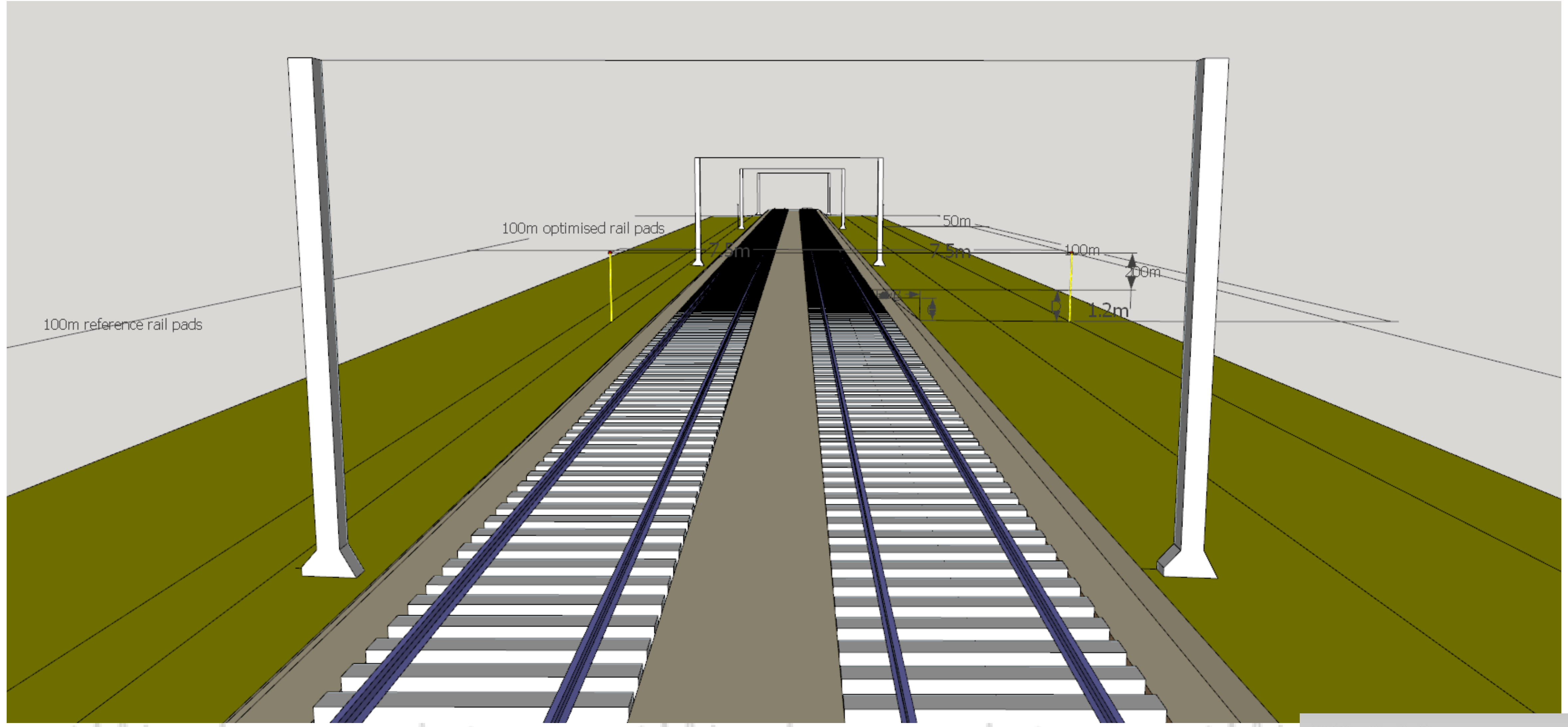
Lp= Lp,track + Lp,veh and Lp,track=Lp +° sep,track

# Test site selection





# Test site selection



## Norms

ISO 3095:2013 Acoustics - Railway applications - Measurement of noise emitted by rail bound vehicles.

EN 15461+A1-2010-2: Characterisation of the dynamic properties of track sections for passby noise measurements

EN 15610 – 2019: Railway applications - Acoustics - Rail and wheel roughness measurement related to noise generation.

## Acoustical considerations

- Availability of recent TDR measurements at known rail **temperature**
- Availability of recent Rail roughness measurements (grinding planning, time delay after last grinding...)
- Quality of the rail running band (no welding, joints, switches, rail discontinuities, squats,..)
- Ballast cross section (geometry, ballast shoulder height to avoid diffraction differences)
- Similar flat or sloped free field (no change in “cross-section” nor obstacles within 22m around microphones)

## Practical considerations

- Type of track, should be the standard track without curves in a good normal condition (age, maintenance: tamping, grinding)
- Rolling stock variation on the selected line (interest in passenger, freight, or both)
- Speed of the section (should be constant, no deceleration or acceleration zone due to signaling due to signaling or nearby station)
- Physical access to the test site (roads, access for installation, protected for public access,..)
- Planning and time required to install both railpads and accelerometers in the track

# Measurements (WP5)

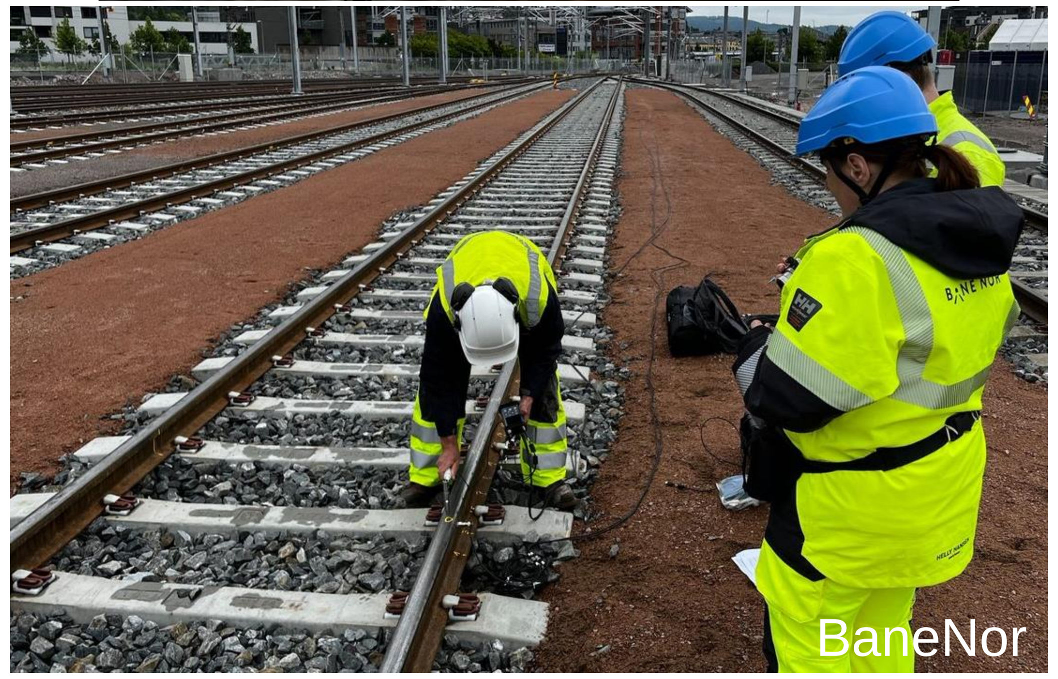


## EQUIPMENT

- Each component of the acoustic instrumentation system shall meet the requirements for a Class 1 instrument specified in IEC 61672-1:2002.
- The compliance of the calibrator with the requirements of IEC 60942:2003 shall be verified at least once a year.
- Microphones with free field characteristics shall be used.
- ISO3095 requirements for instrumentation.

## ADDITIONALLY

- use exactly the same types and sensitivity of accelerometers and microphones at both sections, in order not to introduce already deviations at sensor level.
- sensor fixation on rails, wind protection on the microphone should not be different.
- use one, minimum 4 channel, data acquisition system that captures all signals simultaneously at the same sample rate. (min. 20 kHz, but the higher, the better)
- calibrate the microphones before, during and after the measurement campaign, and record temperature of rails railpad during the whole campaign
- calibration raw data to be saved.


# Measurements (WP5)

Today measurement data available from:

SBB CFF FFS

DB

INFRABEL Right On Track

ÖBB

BANE NOR

Infraestruturas de Portugal

SPRÁVA ŽELEZNIC

TRAFIKVERKET

FERROVIE DELLO STATO ITALIANE

BANE NOR

NetworkRail

SNCF

Data to be expected soon

FERROVIE DELLO STATO ITALIANE — Data OK, but no railpad change possible

ProRail — Data to be expected soon, no railpad change possible

# Results



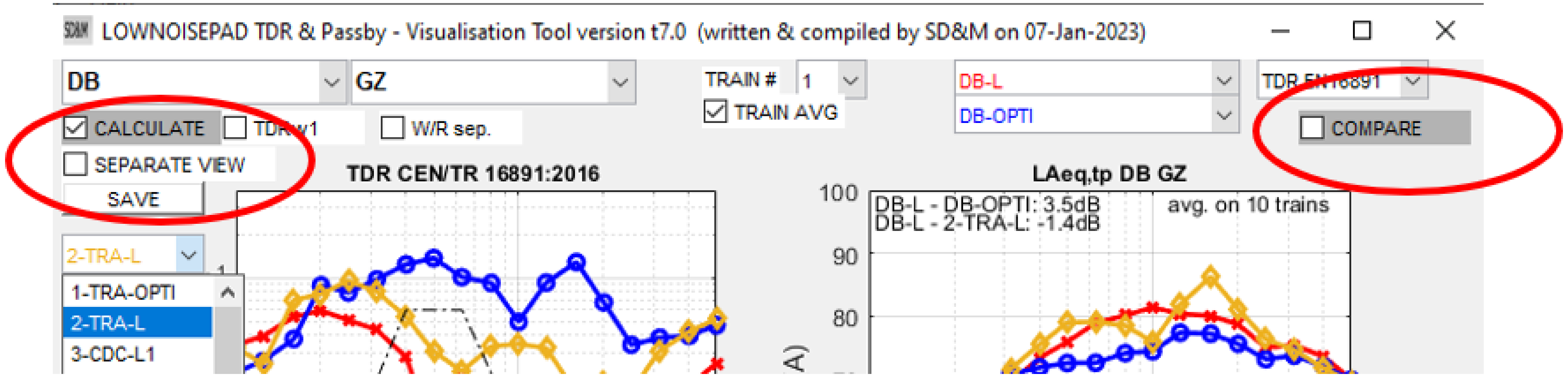
- Main document with all measurement data, processing procedures
- Processing of more than thousand train pass-by
  - Various speeds, rolling stock, temperatures
- Achieved noise reductions at the PP for combinations of 30 different railpads (60- 1000kN/mm)
- Track Decay rates at all the sites

IRS: Track noise measurement guideline -A methodology to measure and compare the noise emitted from different track components

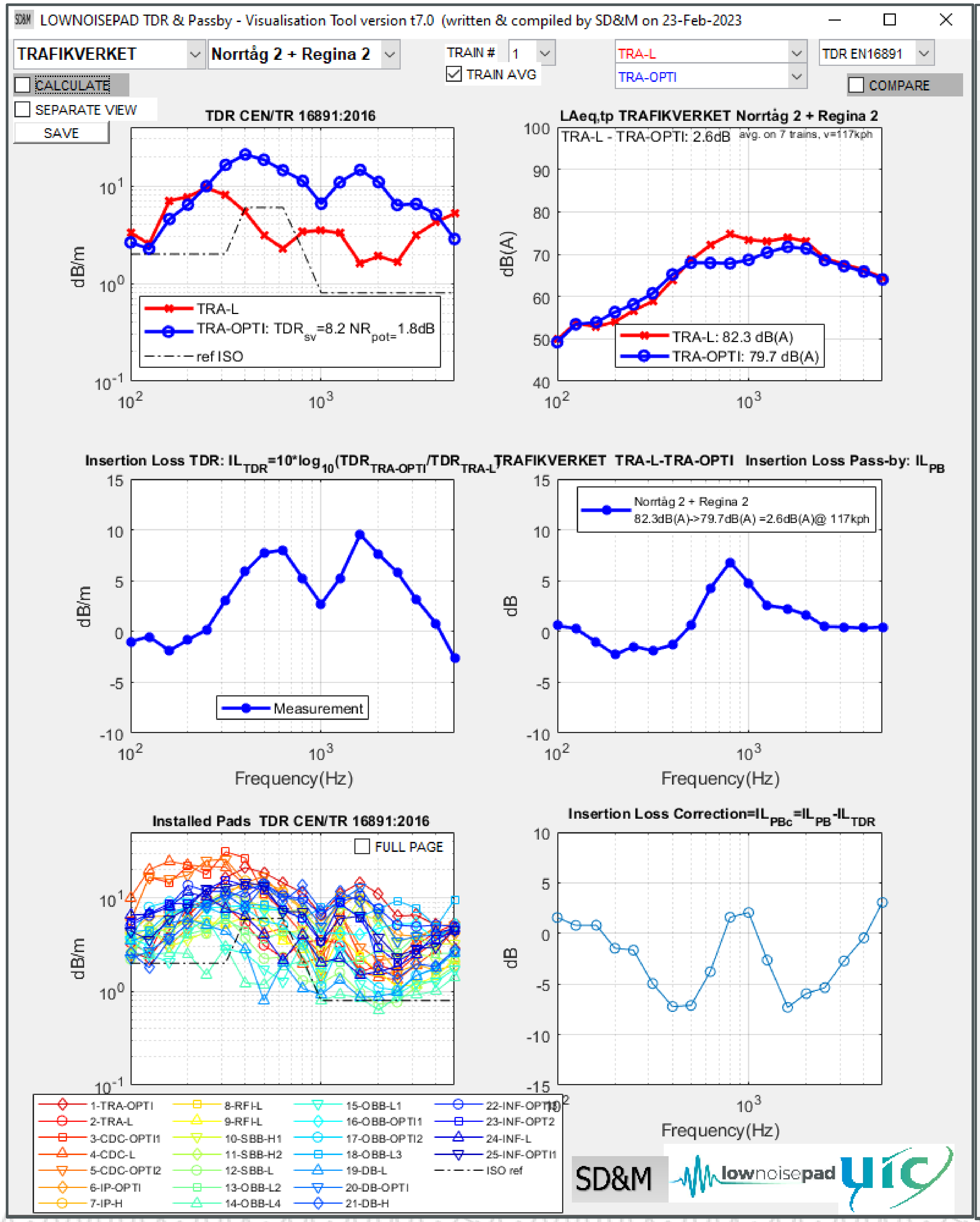
- lownoisepad Software tool (WP6) to display and analyze all measurement data and processing's
  - dBase Pass-by and TDR EN15641 / CEN/TR 16891:2016 with all parameters in 1/3 octave dB/m and dB(A)
  - Estimating of noise reduction (2 methodologies)

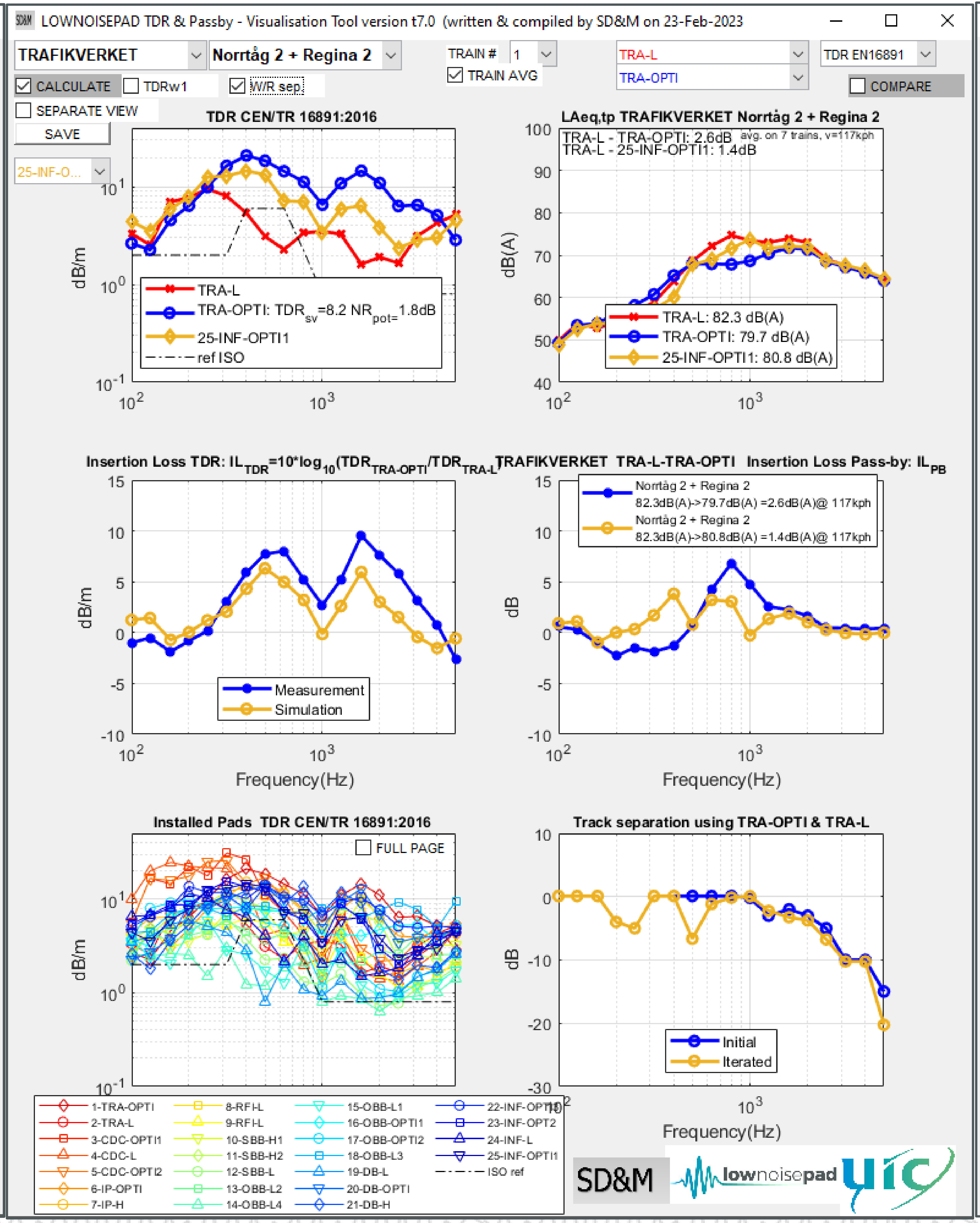
# Results WP6: Softwaretool

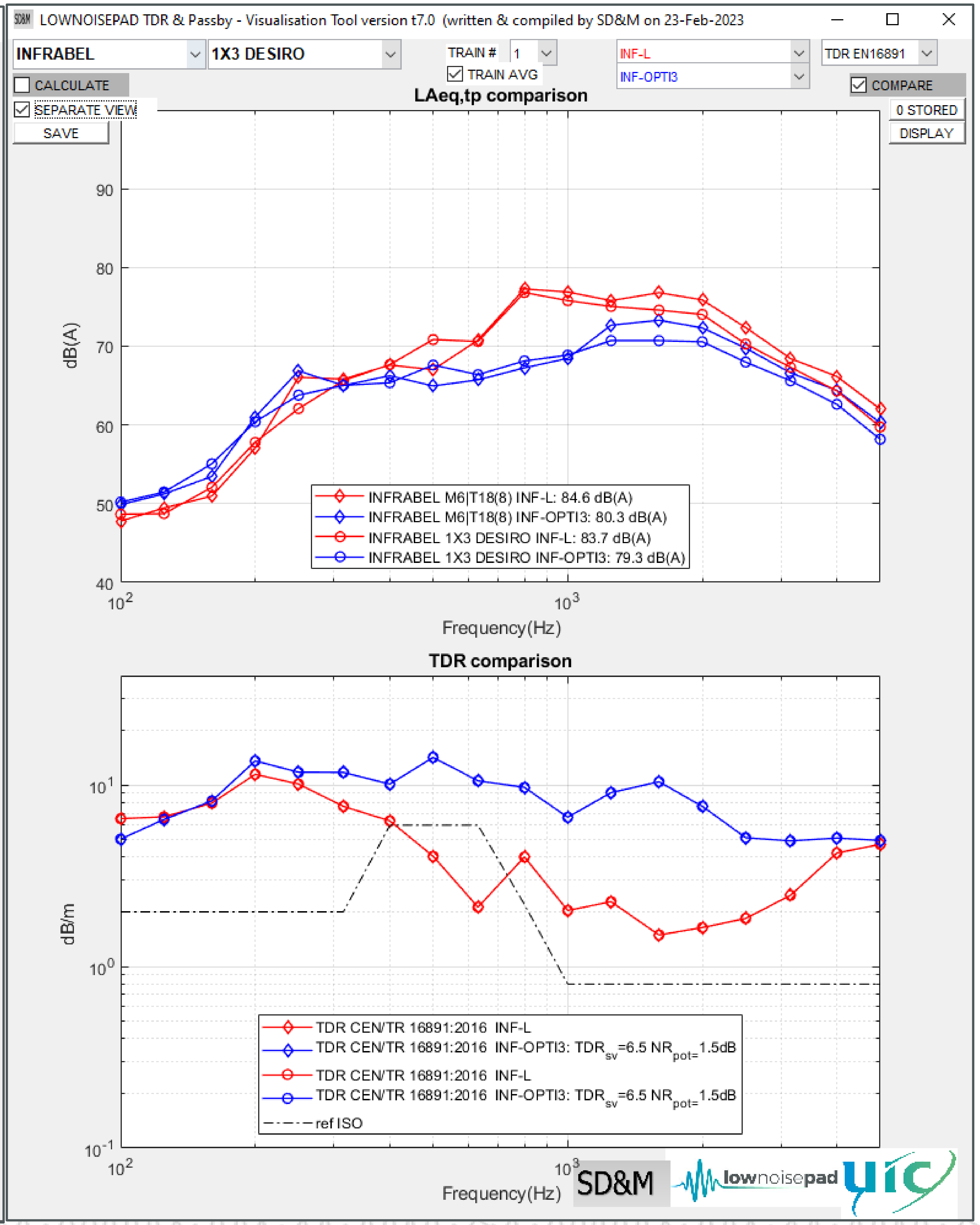
- Runs on Windows systems
  - Password protected
  - Easy installation and use, self explaining menu's
  - Can be extended to visualize other mitigation measures
- 2 main functions
  - **COMPARE** and Visualization of measurements (Pass by and TDR )
    - Possibility to compare trains/tracks between de countries in overlay
  - **CALCULATE** emission changes by "virtually" replace a railpad by one that was tested in other country
    - Using 2 different methodologies (in development)



# Results WP6: Softwaretool



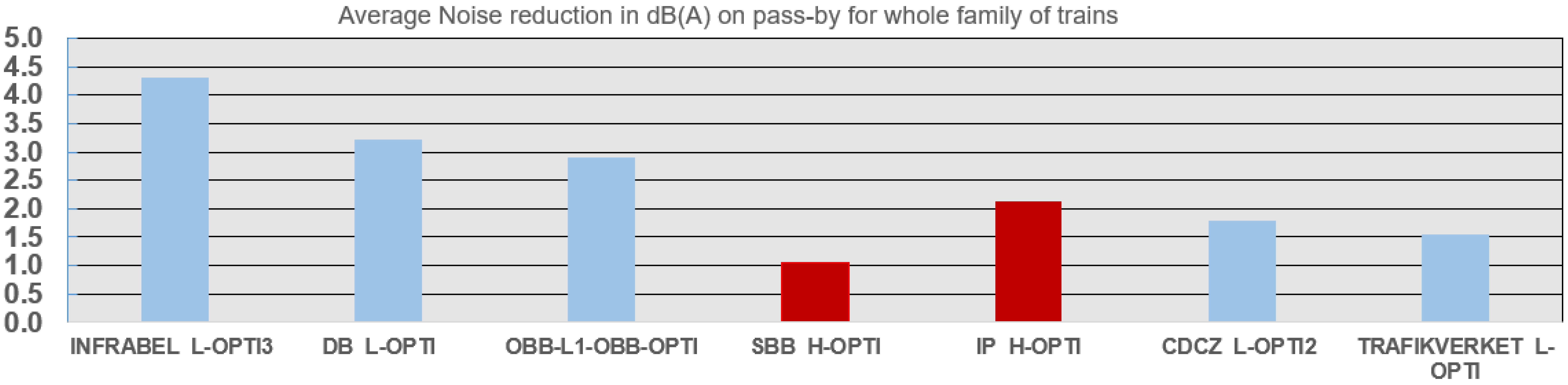



# Results



- Noise reductions for 7 optimized pads **OPTI (between 60-230kN/mm)** referenced to:
  - **SOFT L ( < 200kN/mm) pads**
  - **STIFF H( >500kN/mm) pads**
- Averaged for:
  - various speeds (80-220kph),
  - rolling stock (passenger, freight),
  - temperature (-11°C – +22°C)



# Conclusions



- Convening acoustic and track engineers nationally and internationally to tackle the same challenge
- Carried out a pragmatic International Project, developed within UIC and supported by 12 EU Rail infrastructure managers
- Motivates, supports and enables European rail infrastructure managers to install optimised rail pads and conduct measurements on tracks under operation conditions
- Develop a common understanding and generalised approach through the procedure for installation, measurements, and data-processing: starting from raw unfiltered data as captured, applying ISO3095, EN15641 and CEN/TR 16891:2016
- Seeks a low-cost solution (< 0.5€ extra /m Track), without adding components to the track that requires extra maintenance, instead of extremely expensive solutions as noise barriers (>2000€ /m Track) and rail dampers (> 200€ /m Track)

**Significant noise reduction by installing optimised pads, both for SOFT as STIFF (EVA) pad as reference**

SD&M

STRUCTURAL DYNAMICS & MONITORING

Consulting & research for Railway Noise and Vibration reduction

Eduard Verhelst, Ing, entered INFRABEL, the Belgian Railway Infra manager in 2009 after a career of more then 20 years at Noise & Vibration consulting companies: Dynamic Engineering (Modal analysis/ODS,FEM) and D2S$_{intl}$ (N&V measurements) in Belgium.

At INFRABEL, he designed and installed way-side monitoring stations for static and dynamic wheel/rail forces combined with N&V emission and individual wheel roughness, and train-based track quality monitoring systems, finally resulting in 15 operational double track monitoring stations and 4 operational measurement trains. These monitor the Belgium Railway track quality day-by-day.

At INFRABEL he received a full training as track-engineer by ir. Jan Mys and could acoustically optimize rail grinding activities and rail pads design and properties.

After proposing the LOWNOISEPAD project for UIC, he works now as consultant for UIC to manage this project for 12 European Infra managers, in parallel with consulting activities for various railway product manufactures and Railway Infra managers.

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lownoisepad

**Thank you for your attention.**

## 9:00 – 9:15 Introduction and Welcome Remarks

***Christian Chavanel UIC***, Rail System Department Director

## 9:15 – 10:30 Round Table

Moderated by ***Christian Chavanel UIC*** Rail System Department Director

- ***Europe's Rail JU. Judit Sandor***, program manager for CCA
- ***TTI Sector. David Villalmanzo***, ADIF, chair of the sector
- ***UIC Noise & Vibration Sector. Jakob Oertli***, SBB, chair of the sector
- ***Infrastructure Sector. Franco Iacobini***, RFI, chair of the sector

## 10:30 – 11:00 Coffee Break

## 11:00 – 11:45 UIC Noise Initiatives

***AERONOISE. Gennaro SICA***, HS2 Aeronoise technical leader
***LOWNOISEPAD. Eduard VERHELST***, SD&M, consultant/General Manager

## 11:45 – 12:30 Acoustic Rail Roughness

***Roughness last findings. Survey results. Dimitros Kostovasilis***, WSP
***Acoustic Rail Roughness Working Group. Emilie FREUD***, SBB

## 12:30 – 12:45 Closing Remarks

***David Villalmanzo***, UIC TTI Sector

## 12:45 – 13:00 Sponsors Booth @ Room Stephenson



#UICRailwayNoiseDays
#MoreTrains

# Acoustic Rail Roughness

# ACOUSTIC ROUGHNESS AND MONITORING STUDY

**Dimitrios Kostovasilis**
WSP UK Ltd

UIC Noise Days, Paris, 01 March 2023

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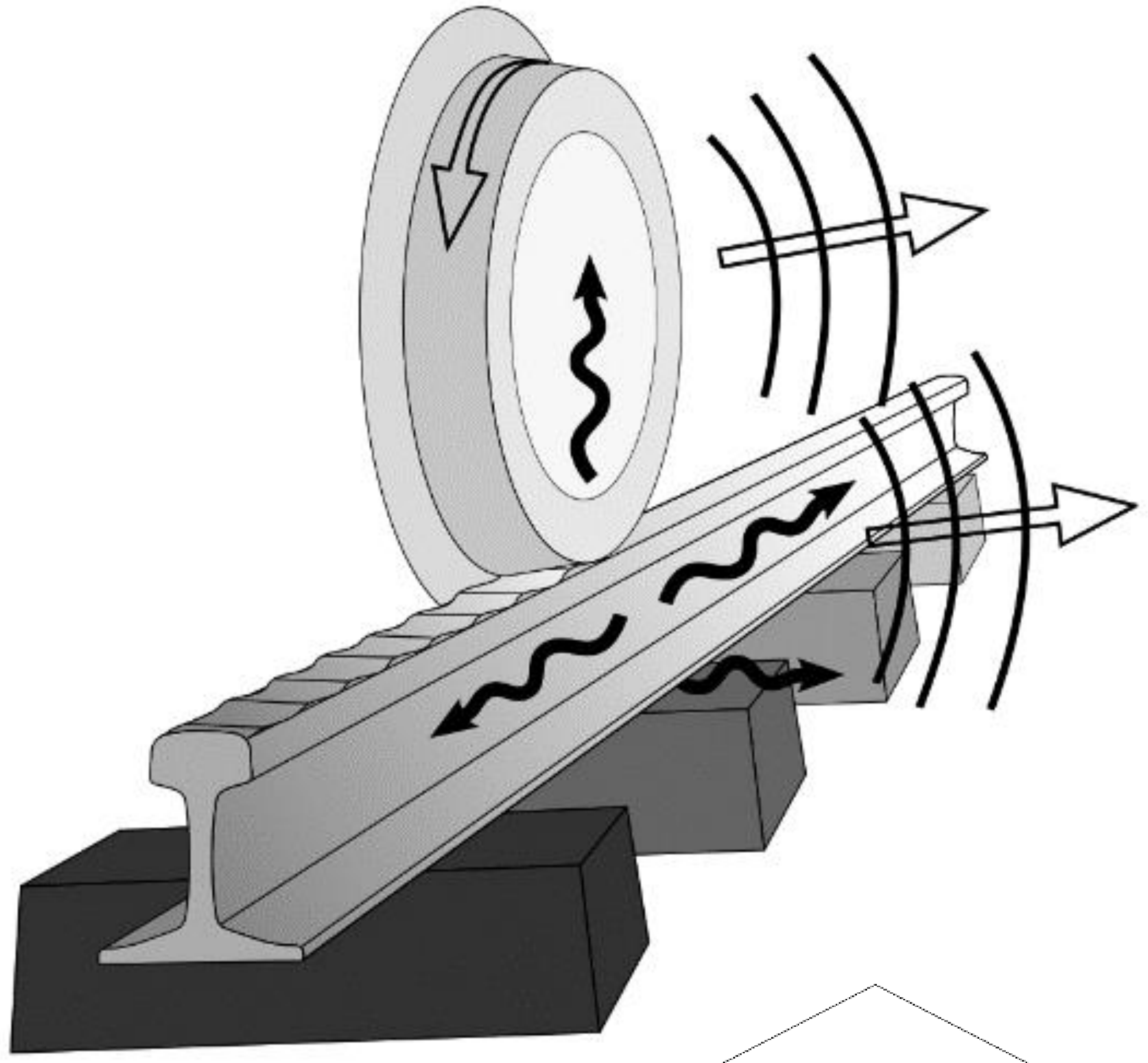
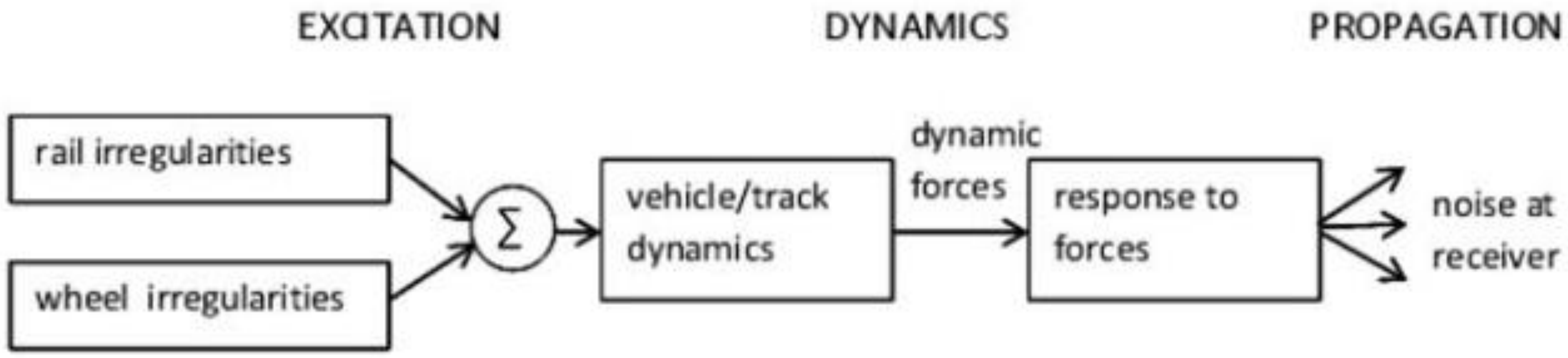
# Noise generation mechanism

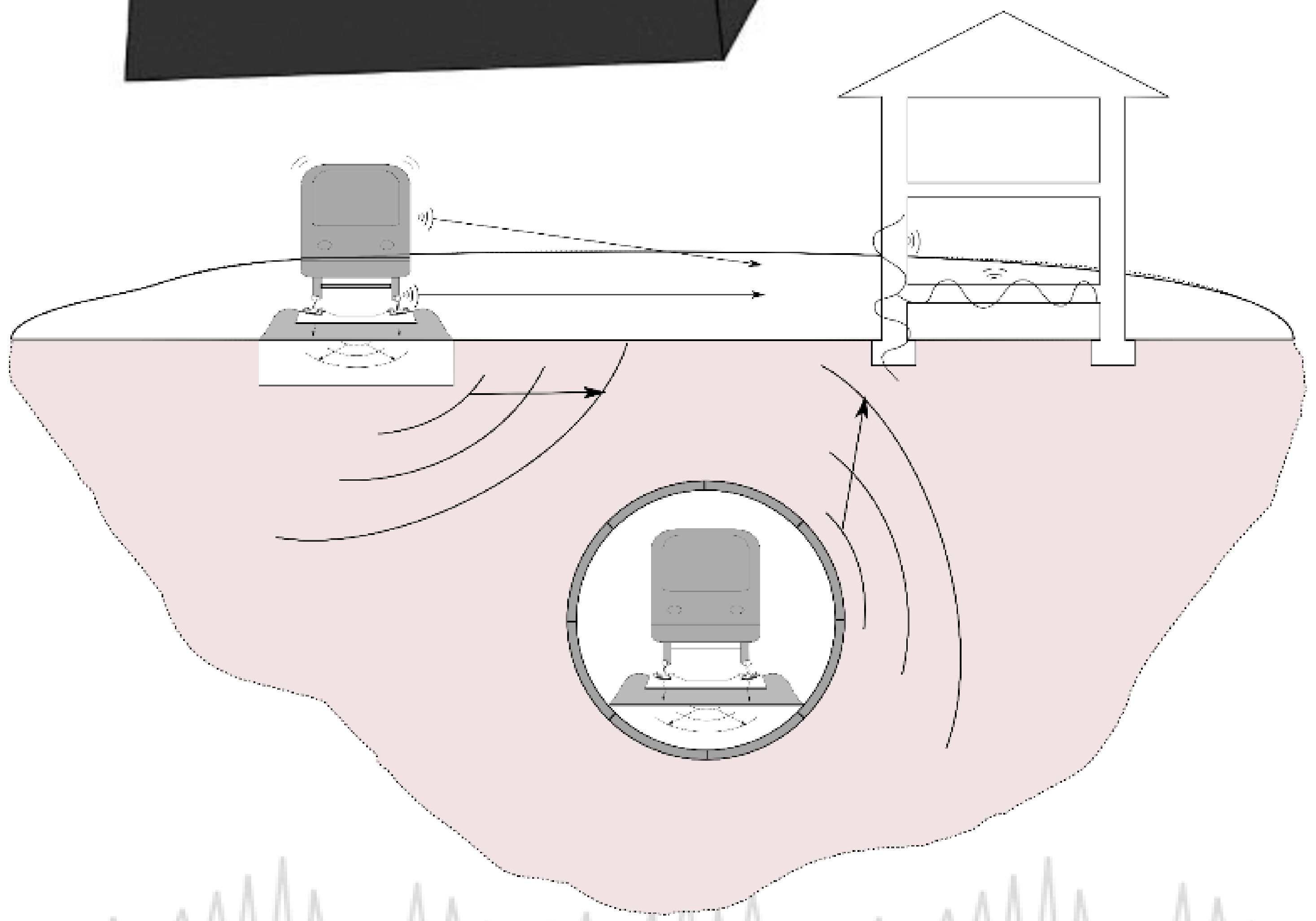


Roughness present at the wheel/rail interface
Affects the excitation forces of train and track
Dynamic excitation of wheel and track structures generates noise

Similar for ground-borne noise and vibration





# Wavelengths of interest



Excitation frequency for noise and vibration proportional to wavelength and speed $f = v/\lambda$

Different sources of unevenness (wheel, rail and track) at different wavelengths

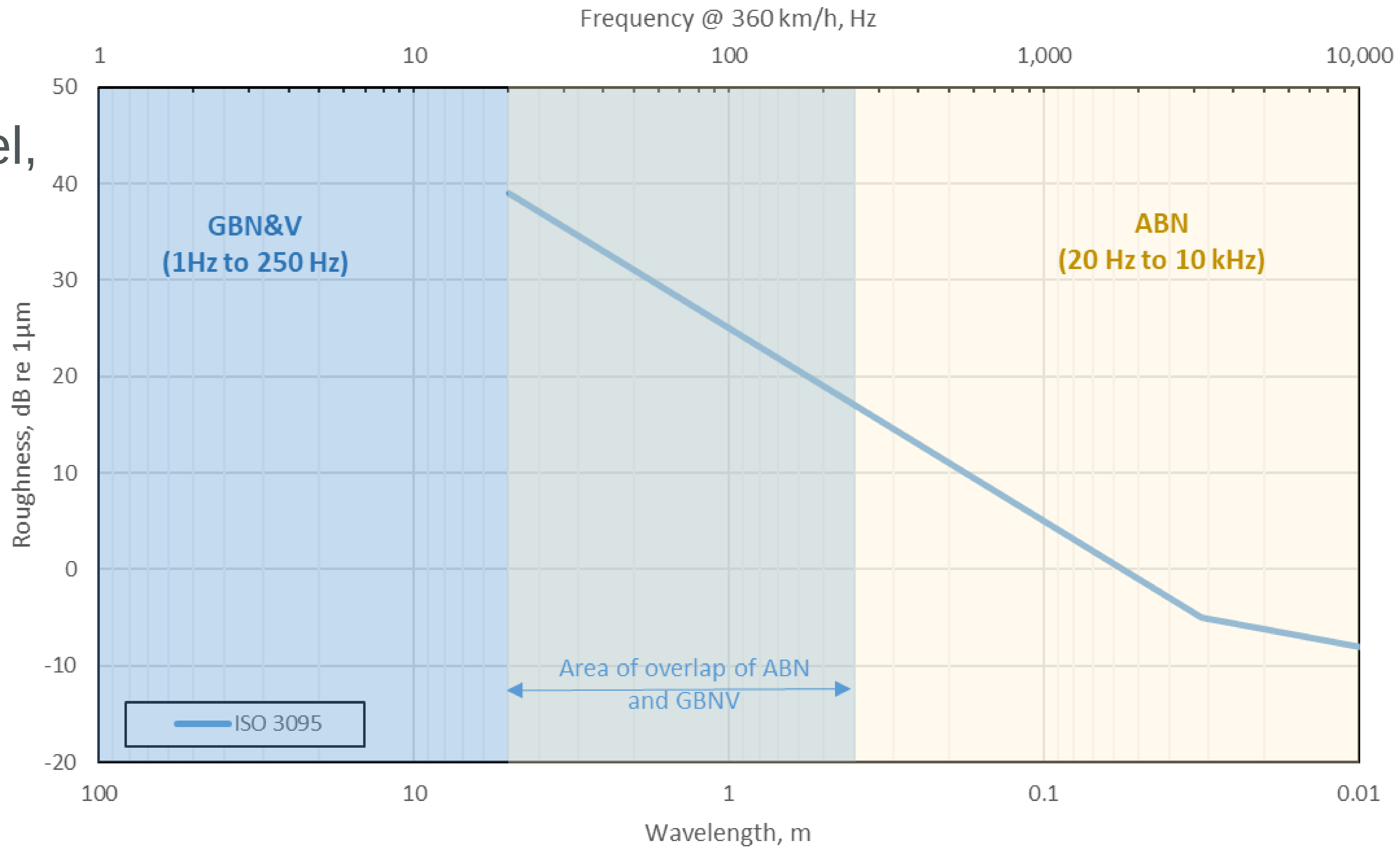
**Rolling Noise**

| | Speed (km/h) | Frequency (Hz) | Wavelength (m) |
|---|---|---|---|
| **Min** | 200 | **20** | **0.006 ~ 0.01** |
| **Max** | 360 | **10000** | 5 |

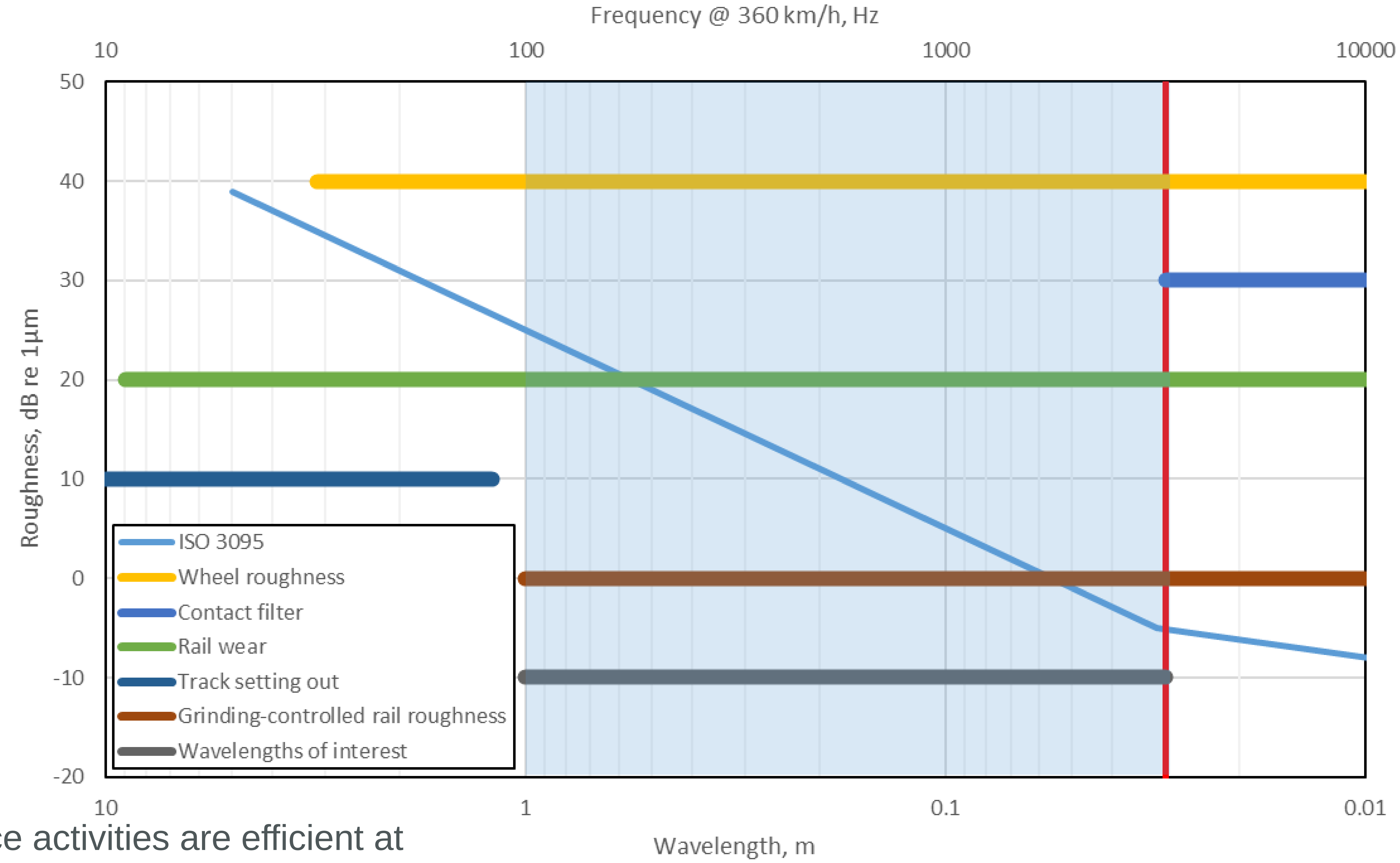
**GBNV**

| | Speed (km/h) | Frequency (Hz) | Wavelength (m) |
|---|---|---|---|
| **Min** | 200 | **1** | 0.222 |
| **Max** | 360 | **250** | **100** |

**Speed shifts freq.**



# Wavelengths of interest




Rail head maintenance activities are efficient at controlling roughness at **30 mm < λ < 250 mm**

# Client's Commitments and implication for roughness/maintenance



Noise Commitment

- Apply to operation and maintenance,
- Degradation of wheel/rail interface over the maintenance cycle, and
- Monitoring noise during operations

Developing a monitoring and maintenance strategy for the wheel/rail interface is key for achieving the noise and vibration commitments

Important to learn best practice in the field from existing railway operator/infrastructure

**Noise and vibration monitoring framework during operation**

- Collect wide range of N&V related data
  - Train, track, noise fence barrier, etc
  - Also *how systems interact* (e.g. track with rolling stock)
- Use to monitor the operational N&V performance

We are as interested in what makes the roughness what it is after 12 months as we are straight after treatment.

# Acoustic Roughness and Monitoring Survey



- We put together an Acoustics Roughness and Monitoring Survey.
- Seven open questions in order to explore the following areas
  - Key factor for track maintenance strategy
  - Acoustics Performance criteria for rail head maintenance
  - Noise Management Issue
  - Monitoring & Management of Acoustics Roughness
- One question on sharing more detailed information / further collaboration

# Engagement via UIC



- Reviewed historical information from UIC on roughness/maintenance provided by the Noise Expert Group
  - Relevant but not comprehensive
  - Little evidence on the actual maintenance criteria driving the strategy and information on specific maintenance treatments
  - Little evidence between maintenance strategy and benefit in terms of noise reduction

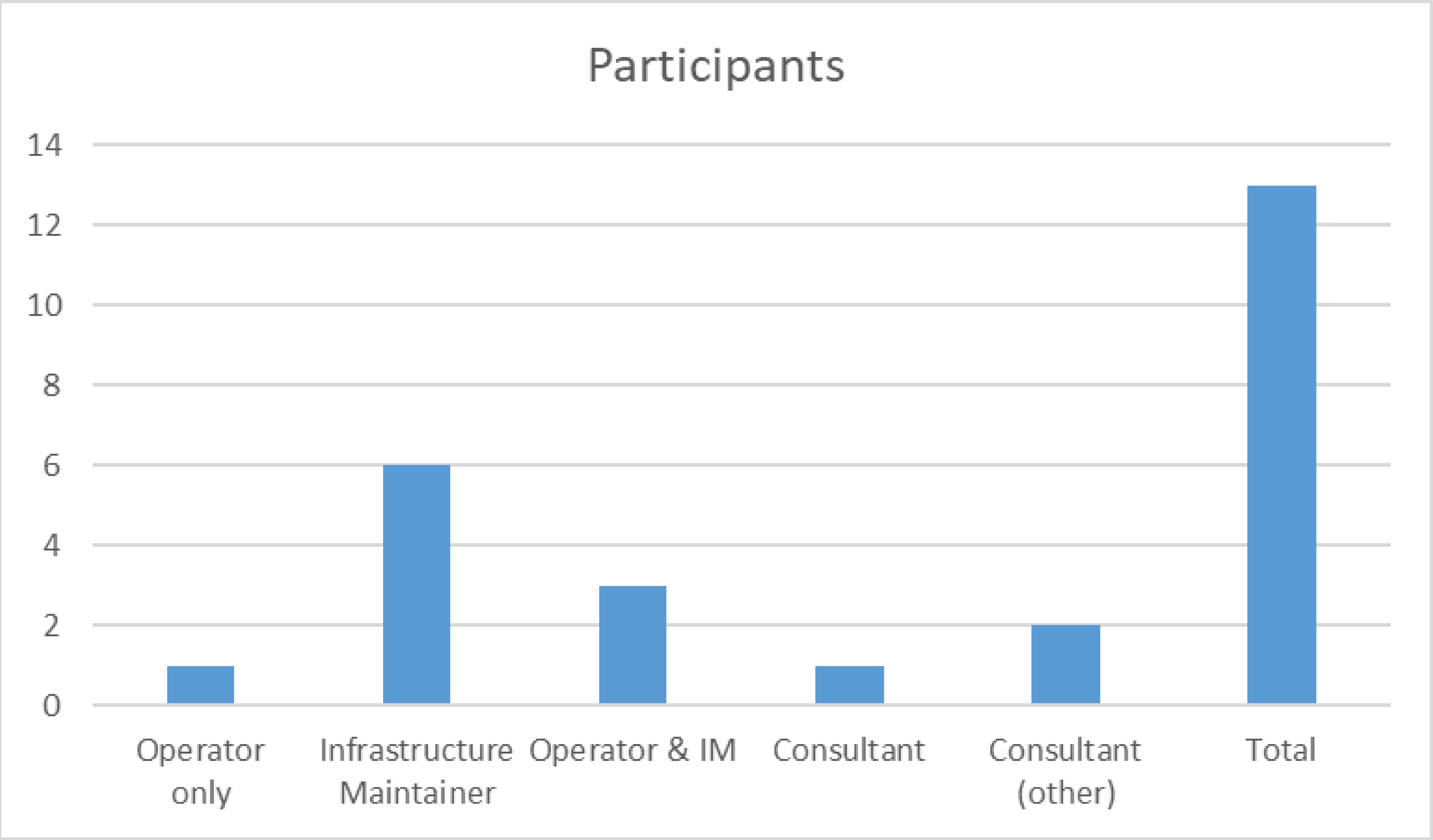
- Engagement with UIC Noise Expert Group (NEG) with the survey
  - Limited response/engagement (2 responses)
  - Noise might not be the main driver in maintaining the rail head?
  - If so, what are the main drivers?

- Involvement UIC Track Expert Group (TEG) members in the survey
  - Better engagement (5 responses)
  - The topic is heavily related to track maintenance and operation.
  - Learning from expertise from key infrastructure managers around the world

    **Enable our track maintenance strategy to be informed by best practice shared by UIC experts**

# Respondents

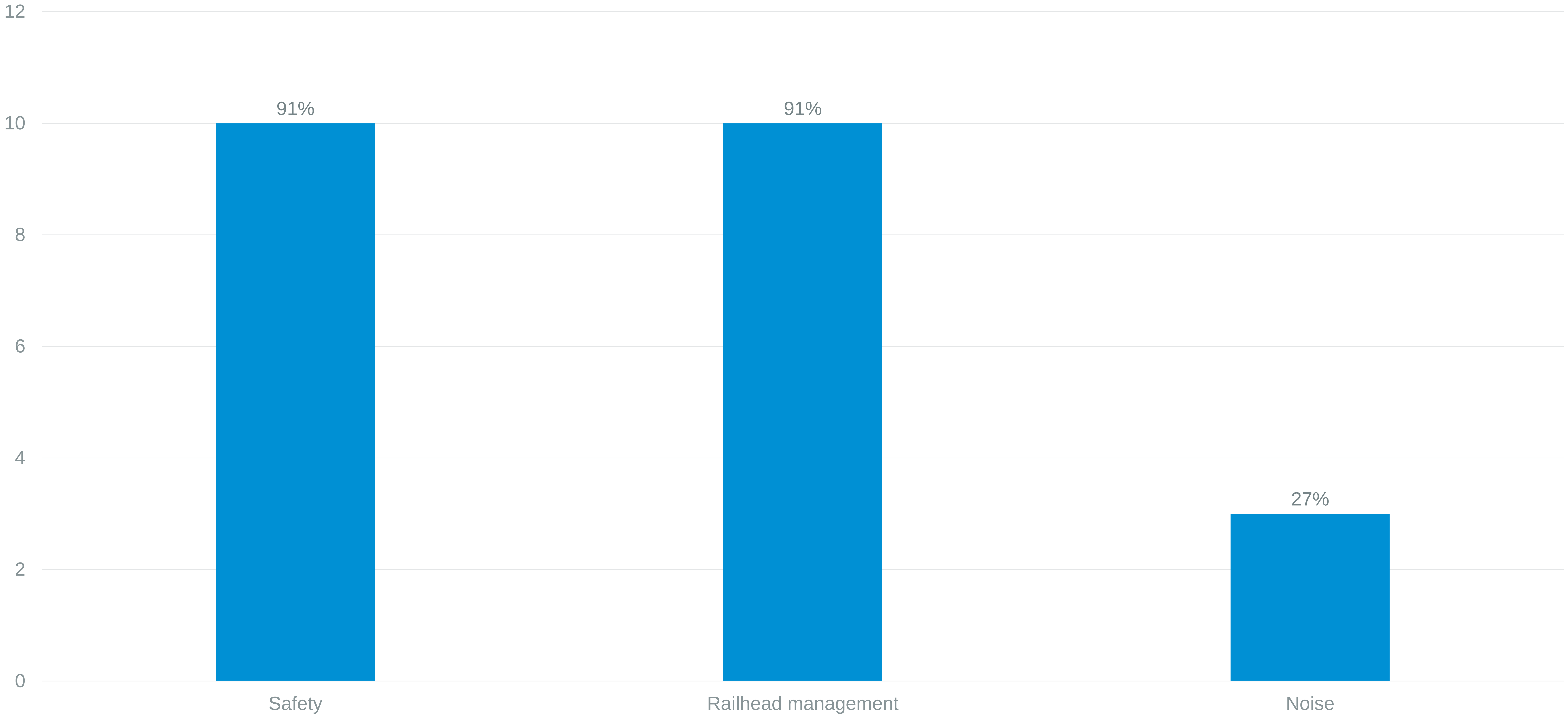





- Two responses from consultancy companies that are not involved with maintenance activities
- Nine out of 11 participants were involved with maintenance activities on high-speed (240 km/h and above) railways

# Q1: What are the key factors that influence your track maintenance (e.g. grinding) strategy?

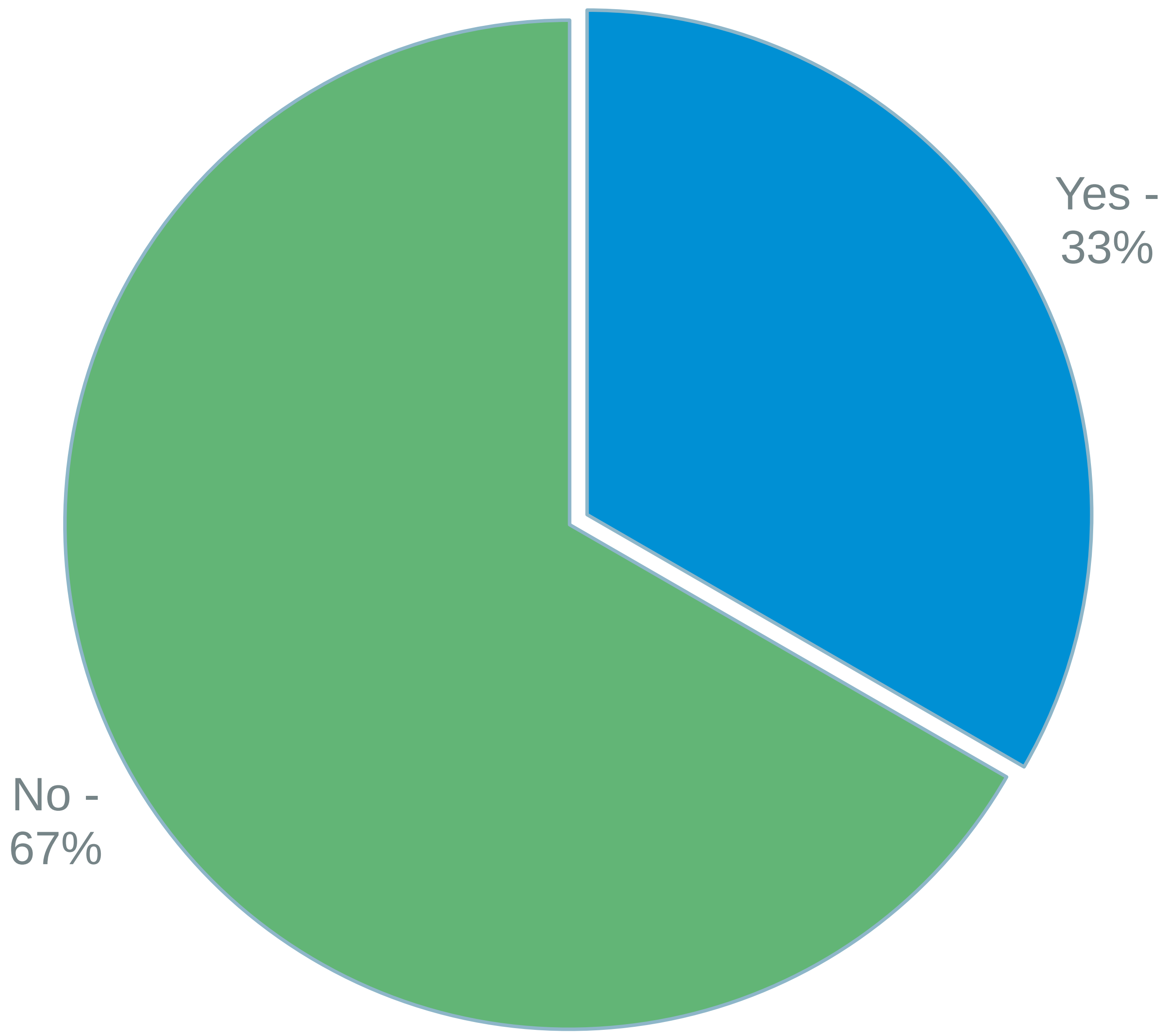




# Q2: When performing rail head maintenance, do you aim to achieve certain acoustic performance criteria?

## Original responses


## Actual acoustic performance criteria

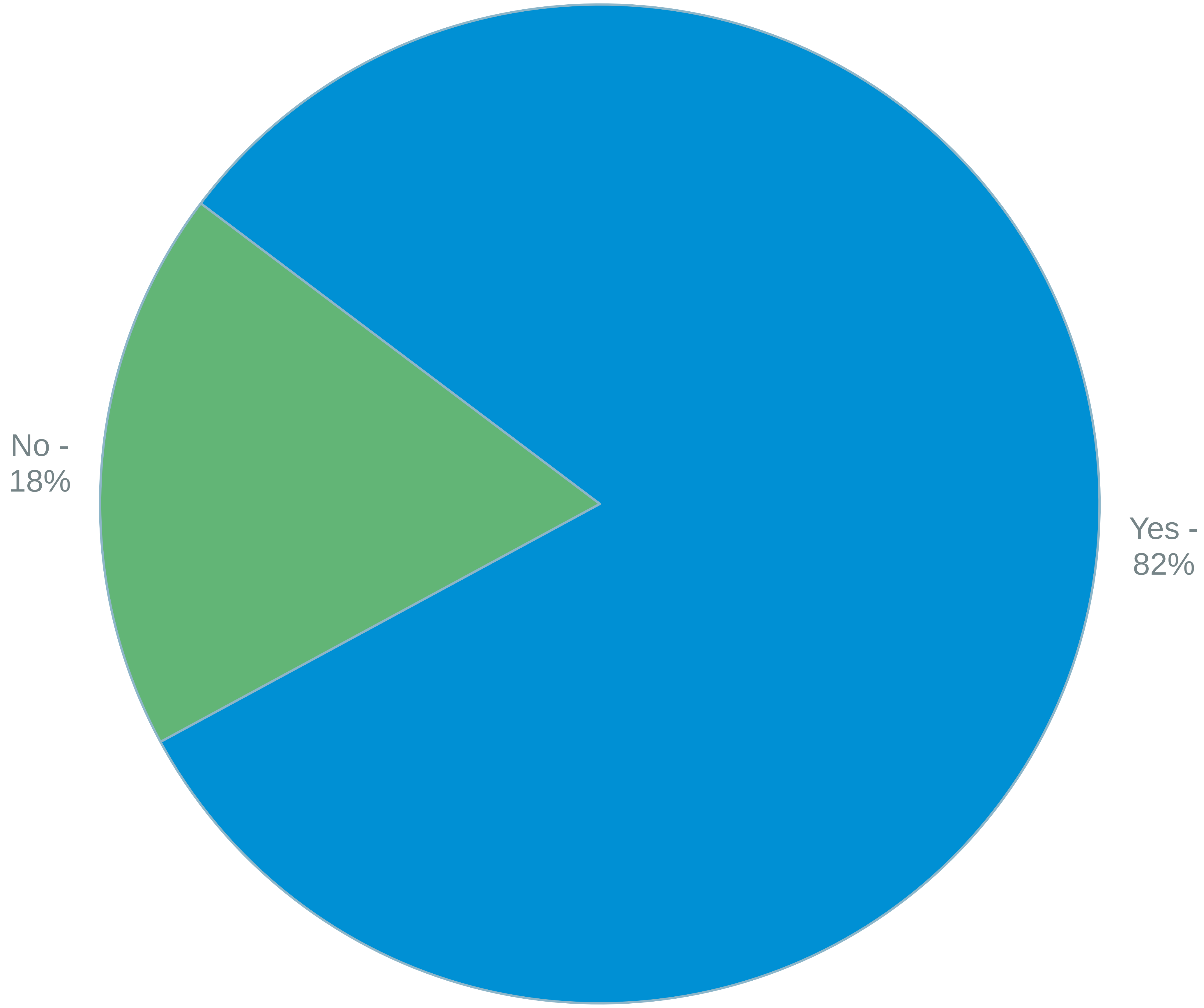


# Q3: Does the condition of your railway cause you noise management issues?



Solution:

- Regular conditioning
- Annual maintenance



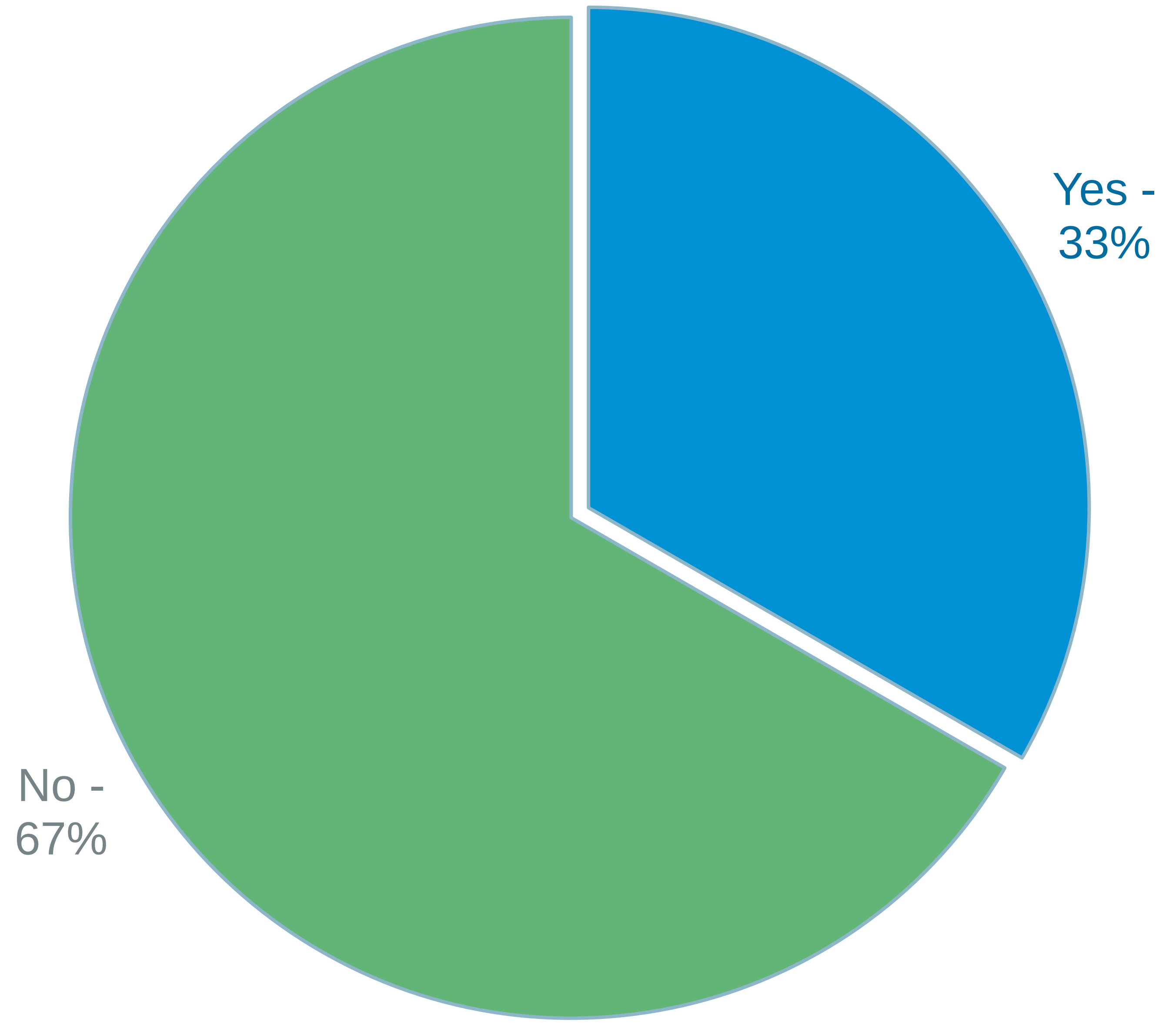

Typical issues:

- Curving noise
- Squeal
- Rolling noise
- S&C noise and vibration
- Vibration

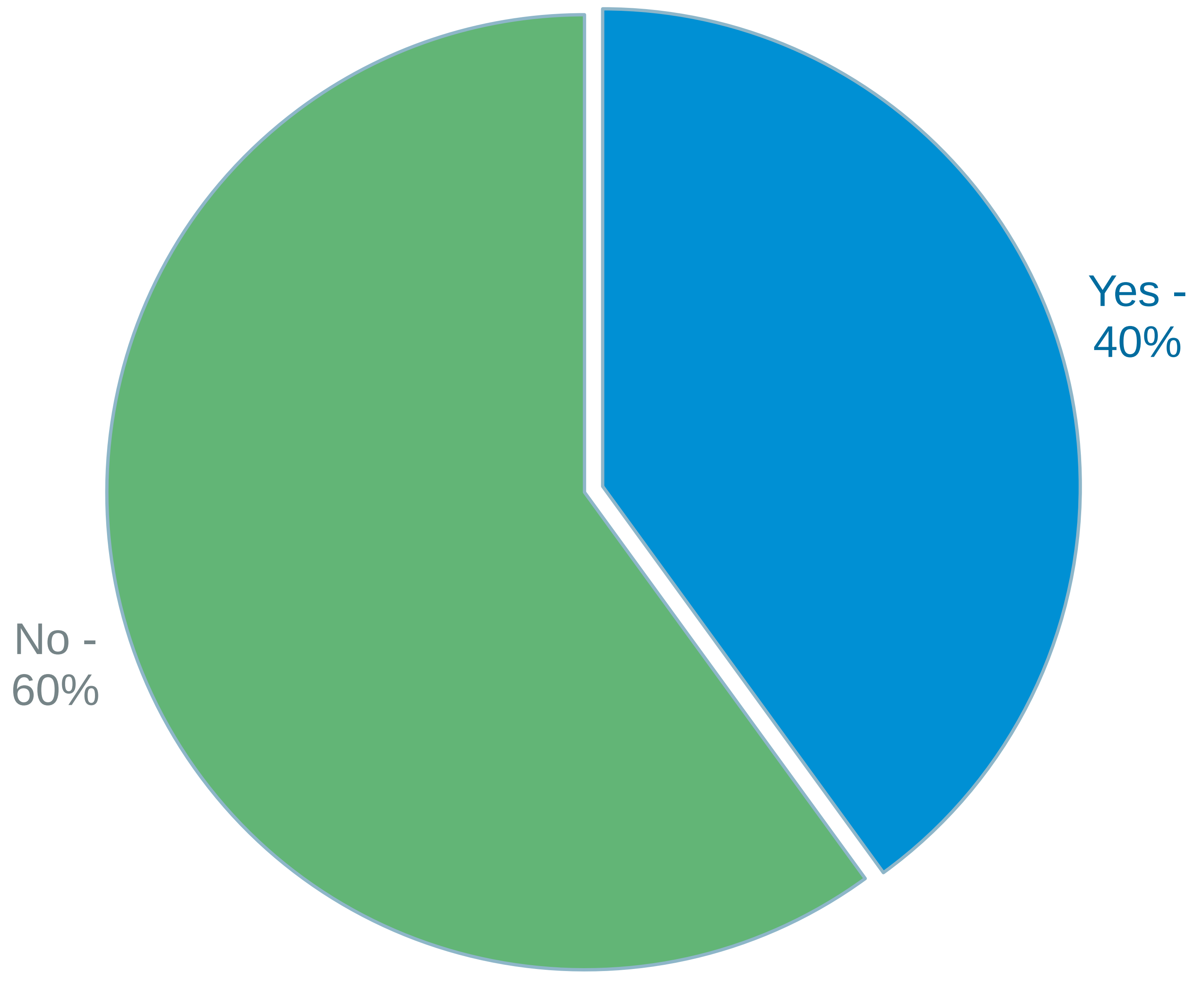
# Acoustic roughness monitoring and information on specific maintenance treatments



Q4: Do you conduct regular monitoring of acoustic roughness levels on your network?

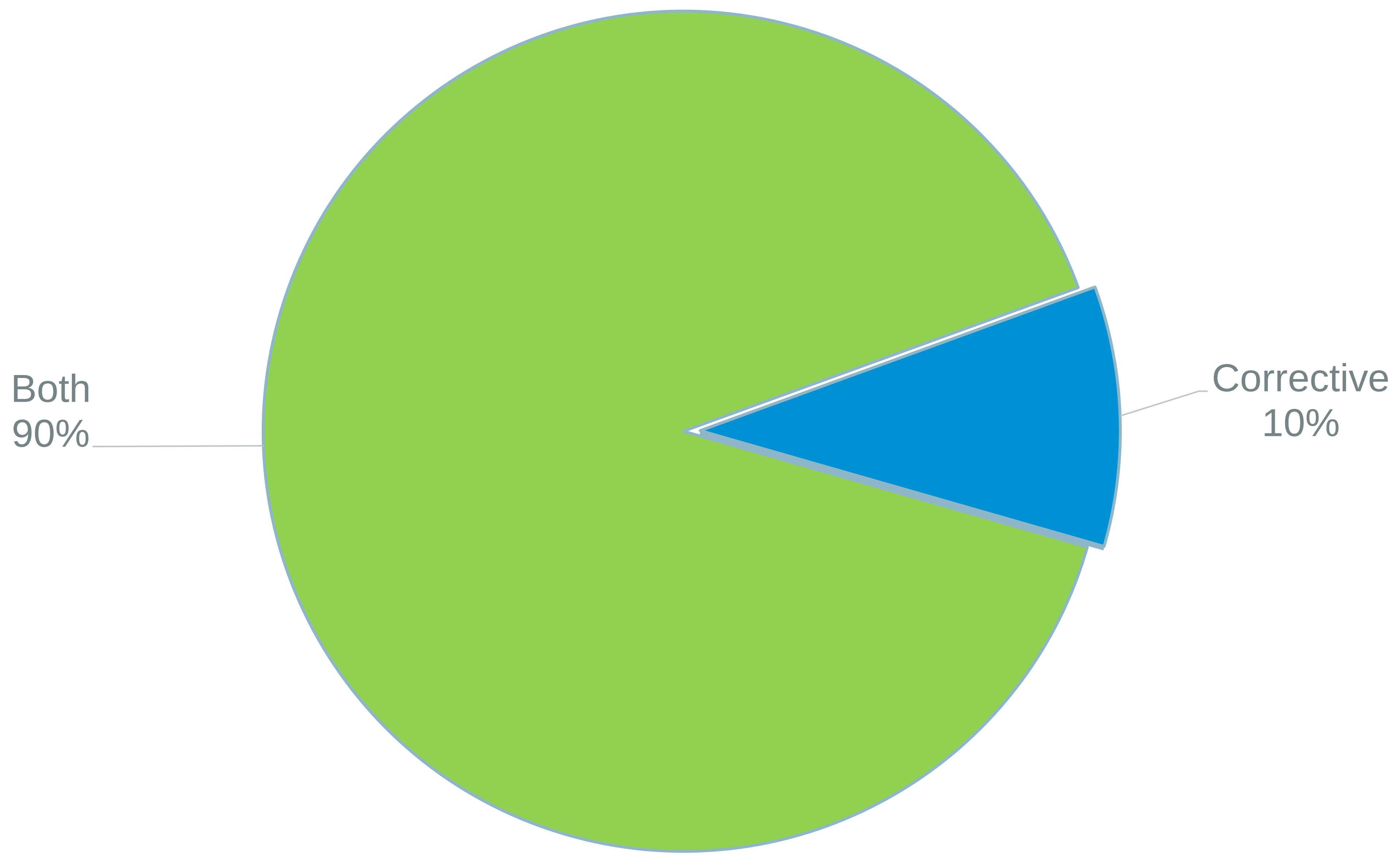



Q5: Do you have information on specific maintenance treatments and evidence of their effect on acoustic roughness?

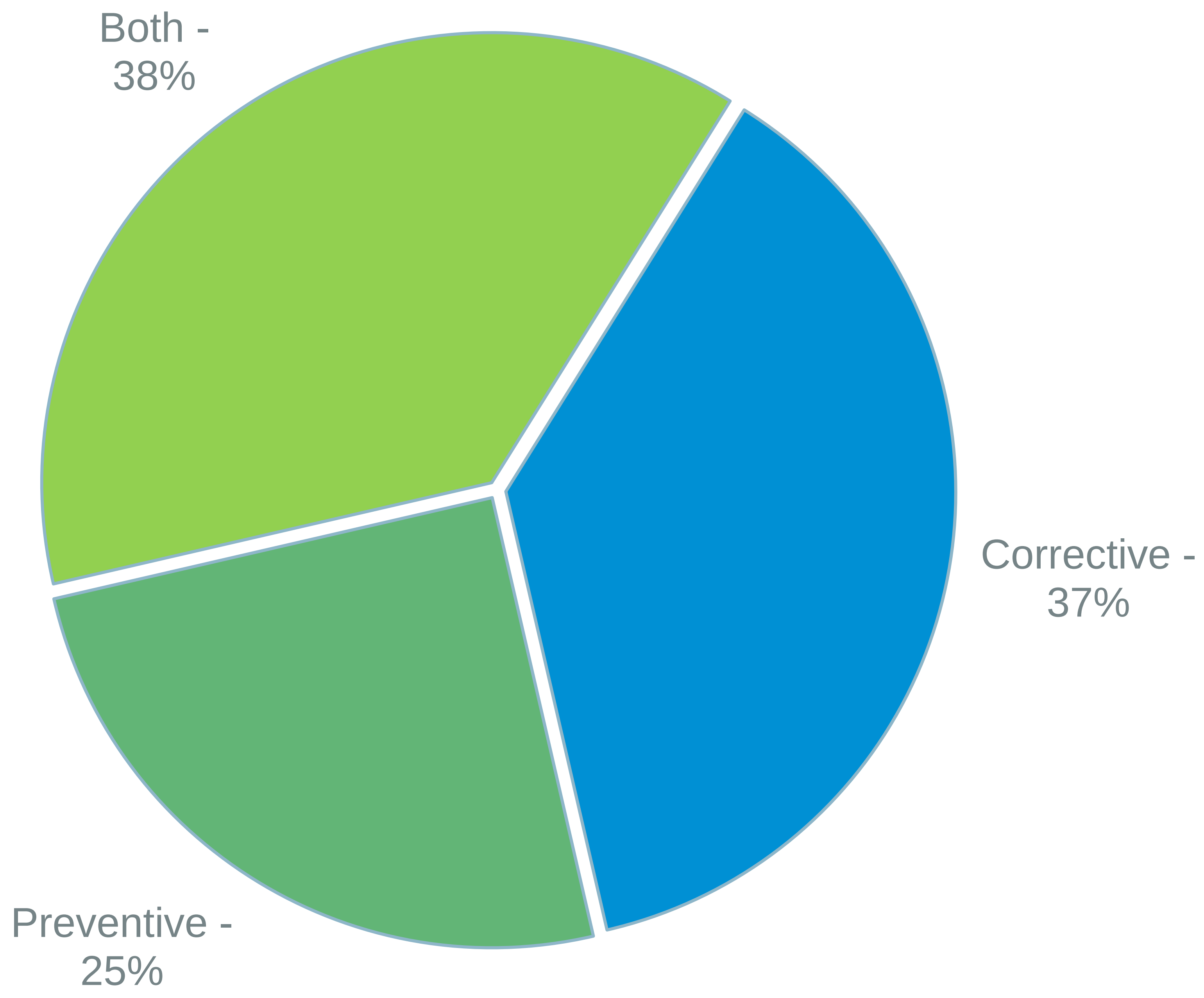


# Maintenance strategy and roughness management

Q6: Is your maintenance strategy preventive, corrective, or both?




Q7: In terms of acoustic roughness management, do you take preventive or corrective steps to address it?



# What are the main drivers for rail head maintenance?

- **“I got 99 problems, but noise ain’t one”?**
- What are the main drivers then?
  - Safety & railhead management
- Noise reduction is a bi-product … or is it?

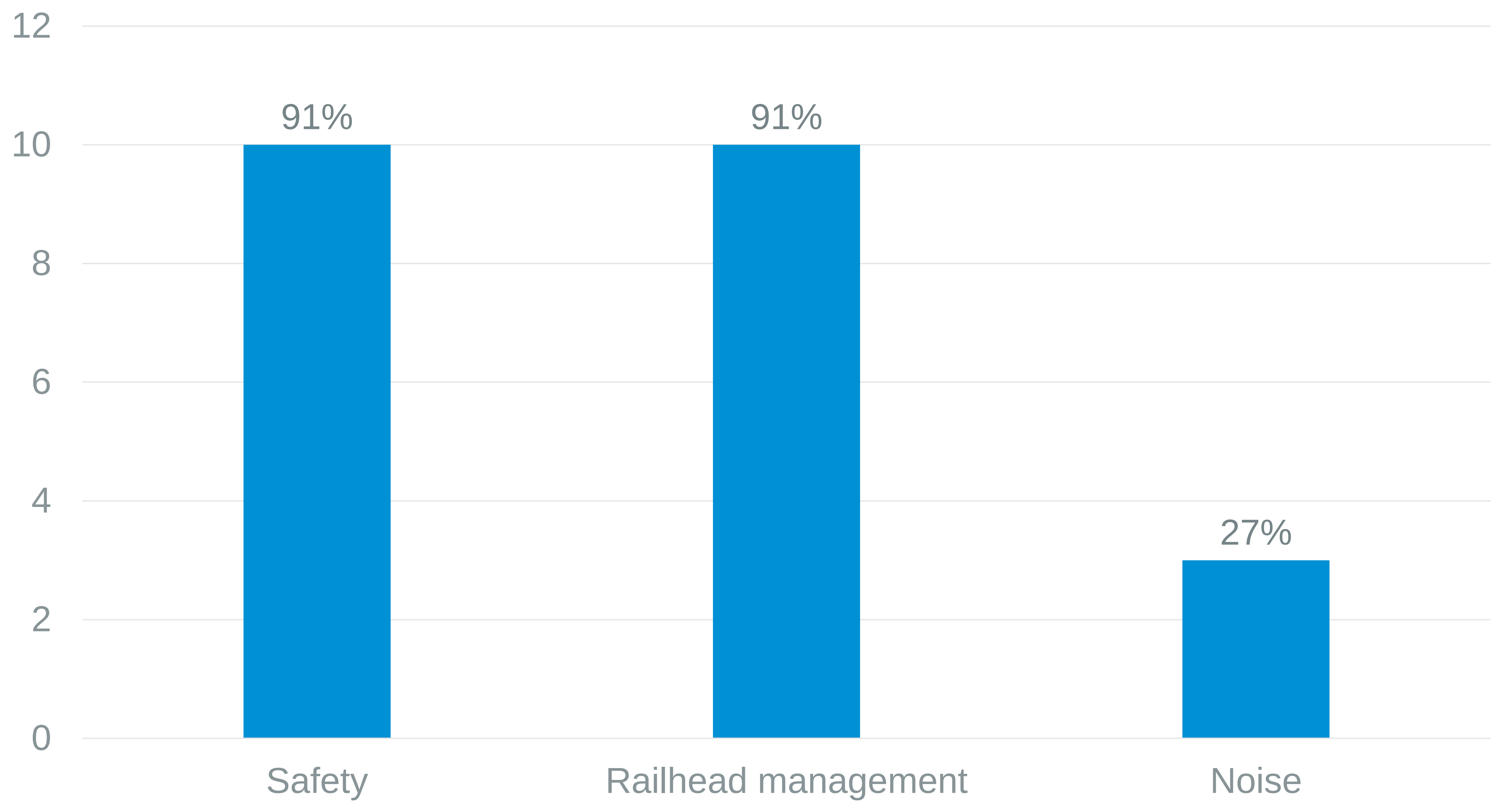
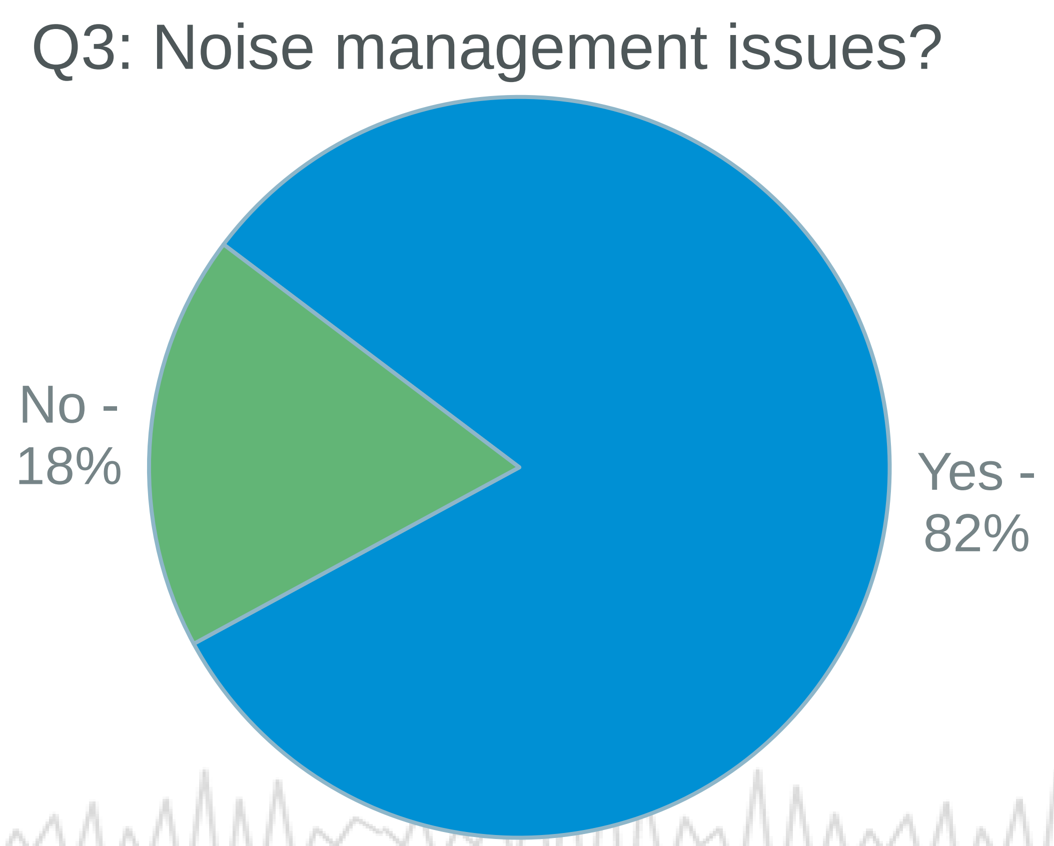



**Table 2.** Track maintenance priority for rail corrugation defects (H: High; M Medium; L: Low).

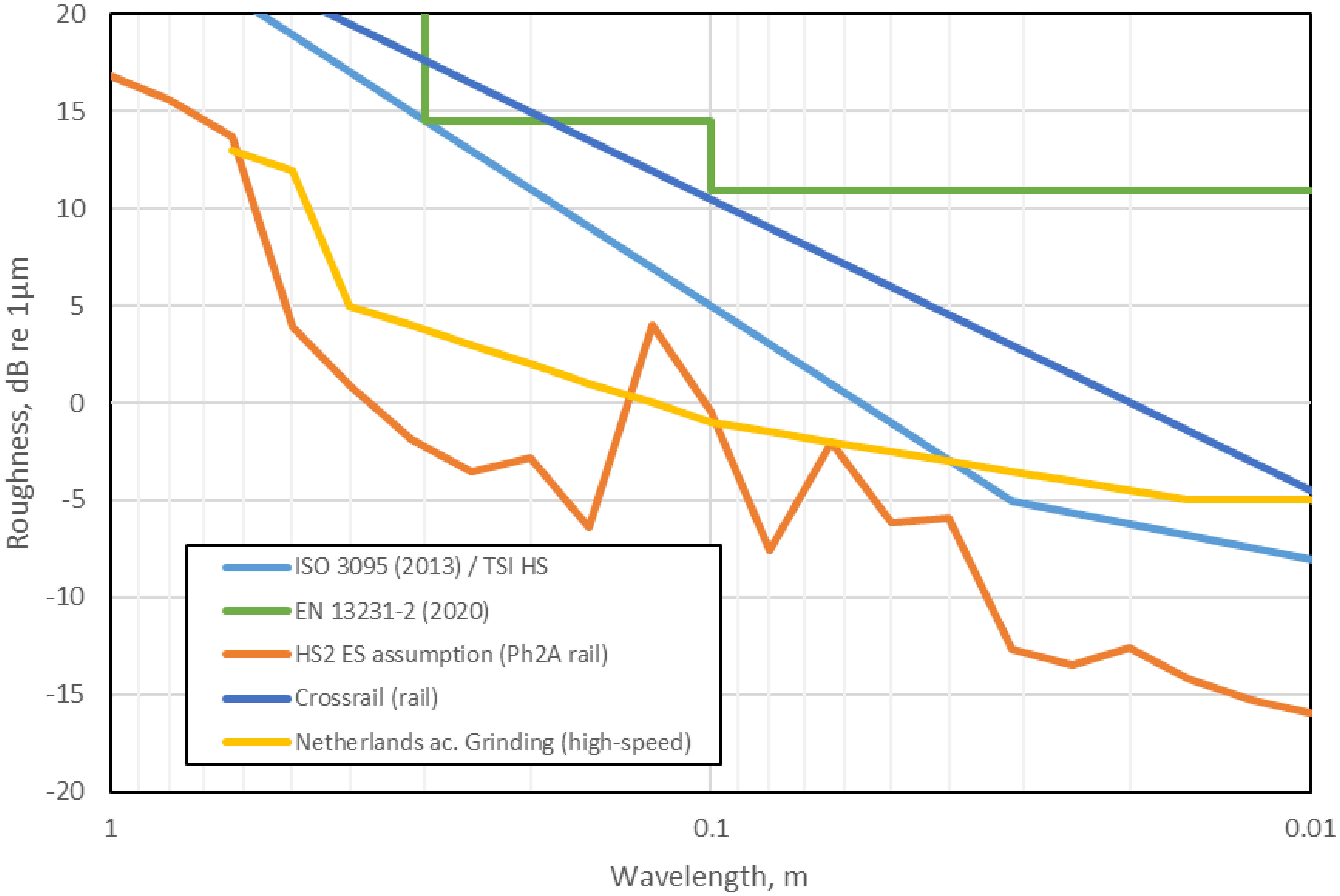
| Feasible causes to railway systems | Operational Risk | Safety Risk | Priority Ranking |
|---|---|---|---|
| Track damages (cracked/broken components) | H | H | 1 |
| Train damages (coupler failure, loosen components) | H | H | 2 |
| Plastic deformation/lipping/tight gauge/source to regenerate other rail defects | M | H | 3 |
| Signal equipment failure from vibrations | M | M | 4 |
| Ground-borne vibrations | M | M | 5 |
| Poor ride quality | M | L | 6 |
| Environmental noise | M | L | 7 |

Source: Kaewunruen (2018)



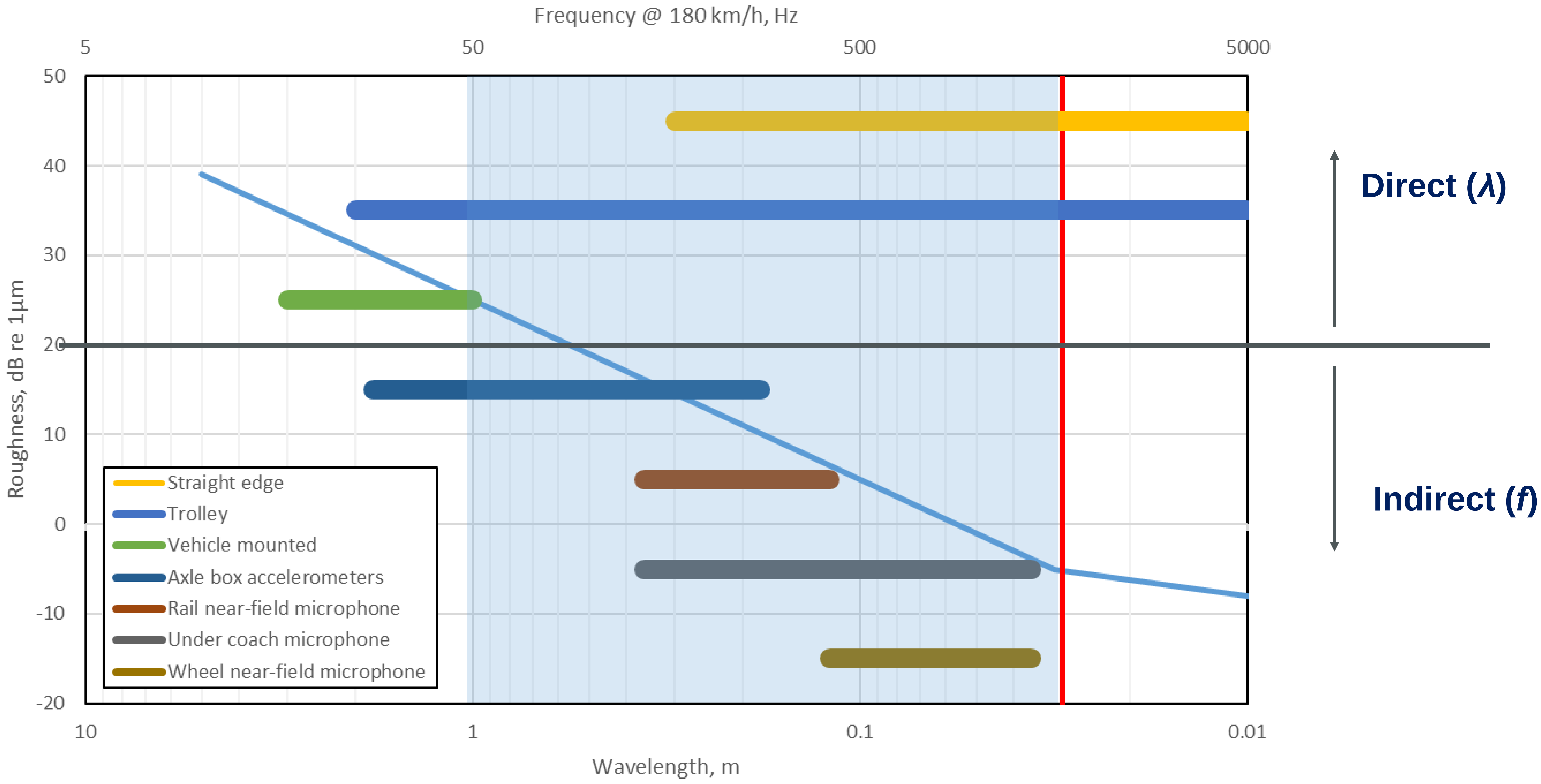
# Standards and industry specifications





# Rail roughness monitoring





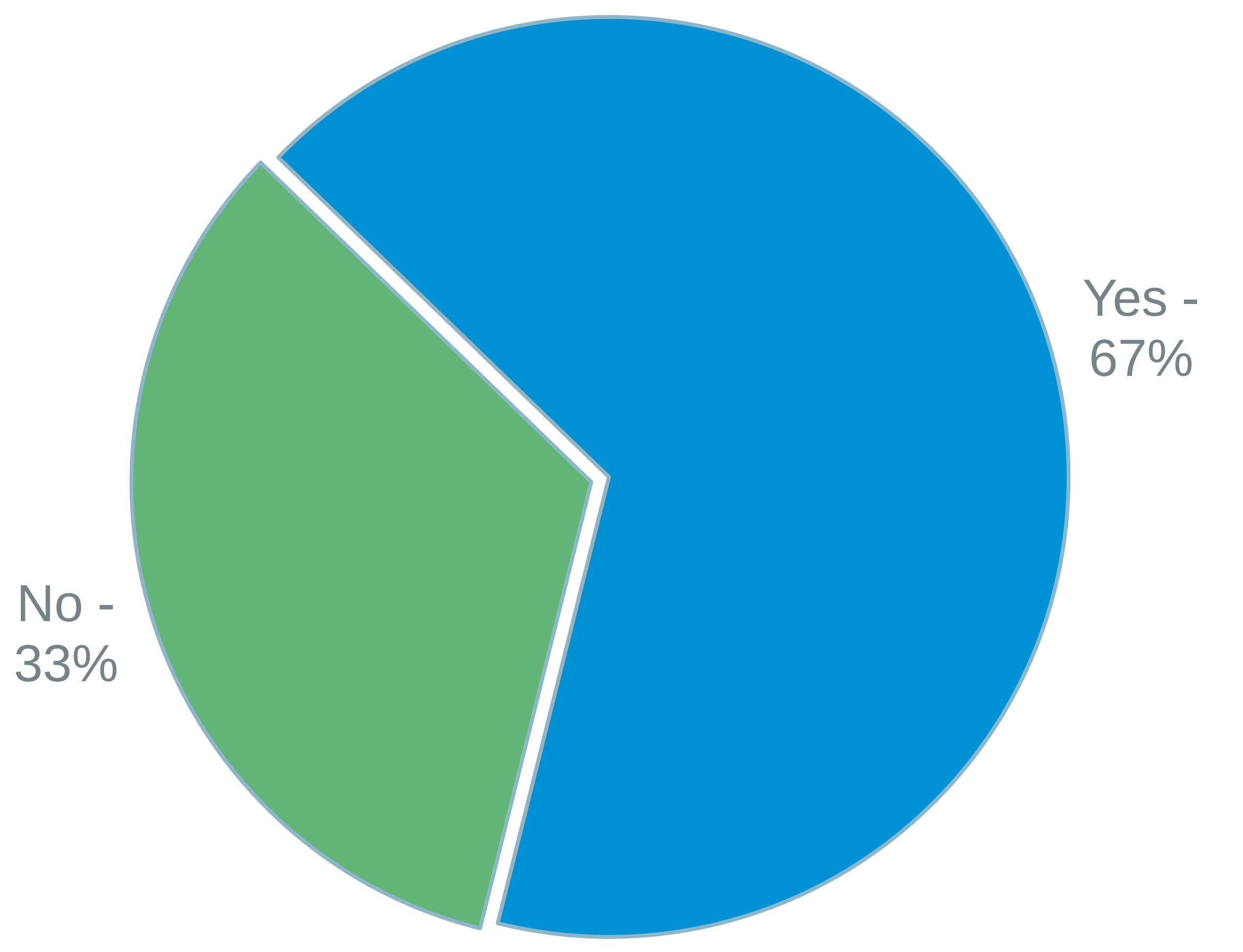
# What is the optimum track maintenance?



- Unavoidably driven by safety/rail life longevity needs
- Preventive rail grinding (yearly?) better than corrective rail head treatment
  - Optimise grinding/treatment parameters for acoustics (quality index?)
    - How is this translated to the maintainer 'language'?
  - Parallel acoustic maintenance to reduce N&V (not additional)
  - Oscillating and high-speed grinding can more-readily deliver low acoustic roughness
- A 'system approach': rail & wheel roughness
- Active monitoring: tight control on acoustic roughness levels (guides treatment)
- Adaptive maintenance regime – monitor and adjust
- Understand the acoustic roughness growth

**Evidence shows that a carefully controlled rail head treatment can have good acoustic performance** – *Get it right first time!*

Q2: When performing rail head maintenance, do you aim to achieve certain acoustic performance criteria?



# Conclusions



- Different roughness generation mechanisms exist that make maintenance operations site-specific;
- There is no widely accepted model for the prediction of roughness growth;
- There is no widely adopted rail head maintenance strategy for acoustics;
- Acoustic track roughness control could add constraints to rail head maintenance operations; and
- Information on the effects of specific rail head treatment activities is sparse, typically confidential to infrastructure maintainers.

**The contribution of UIC has been pivotal to help identify the current gaps in the state of the art and**

**Further collaboration is required within experts of acoustic rail roughness**: more work is required on the assessment of the acoustic quality of railhead treatments and best practice for the measurement of acoustic rail roughness, in order to inform the best practice for maintaining a quiet railway in a cost effective way!

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# ACOUSTIC RAIL ROUGHNESS WORKING GROUP (ARR WG)

## UIC Noise and Vibration Sector

**Emilie Freud, SBB Infrastructure**

UIC Noise Days, Paris

01/03/2023

# The importance of rail roughness for rolling noise

At common speeds, railway noise is mostly generated through the wheel-rail interaction.

Up to now, the effort to reduce rolling noise has been focused on measures applied to :

- the rolling stock (e.g. composite brake blocks)
- the noise propagation path (e.g. noise barriers, acoustically insulated windows)
- the track (e.g. rail pads, rail dampers)

The current projects on rail roughness address the issue directly at the source: at the wheel-rail contact.

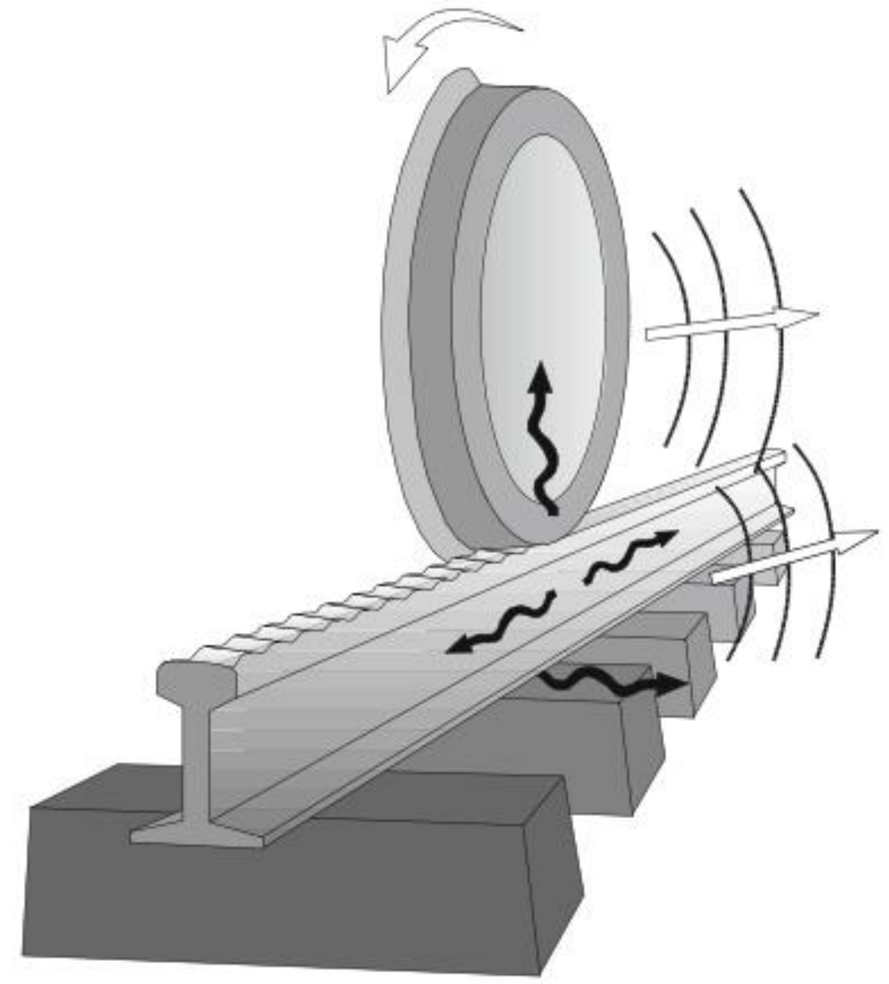
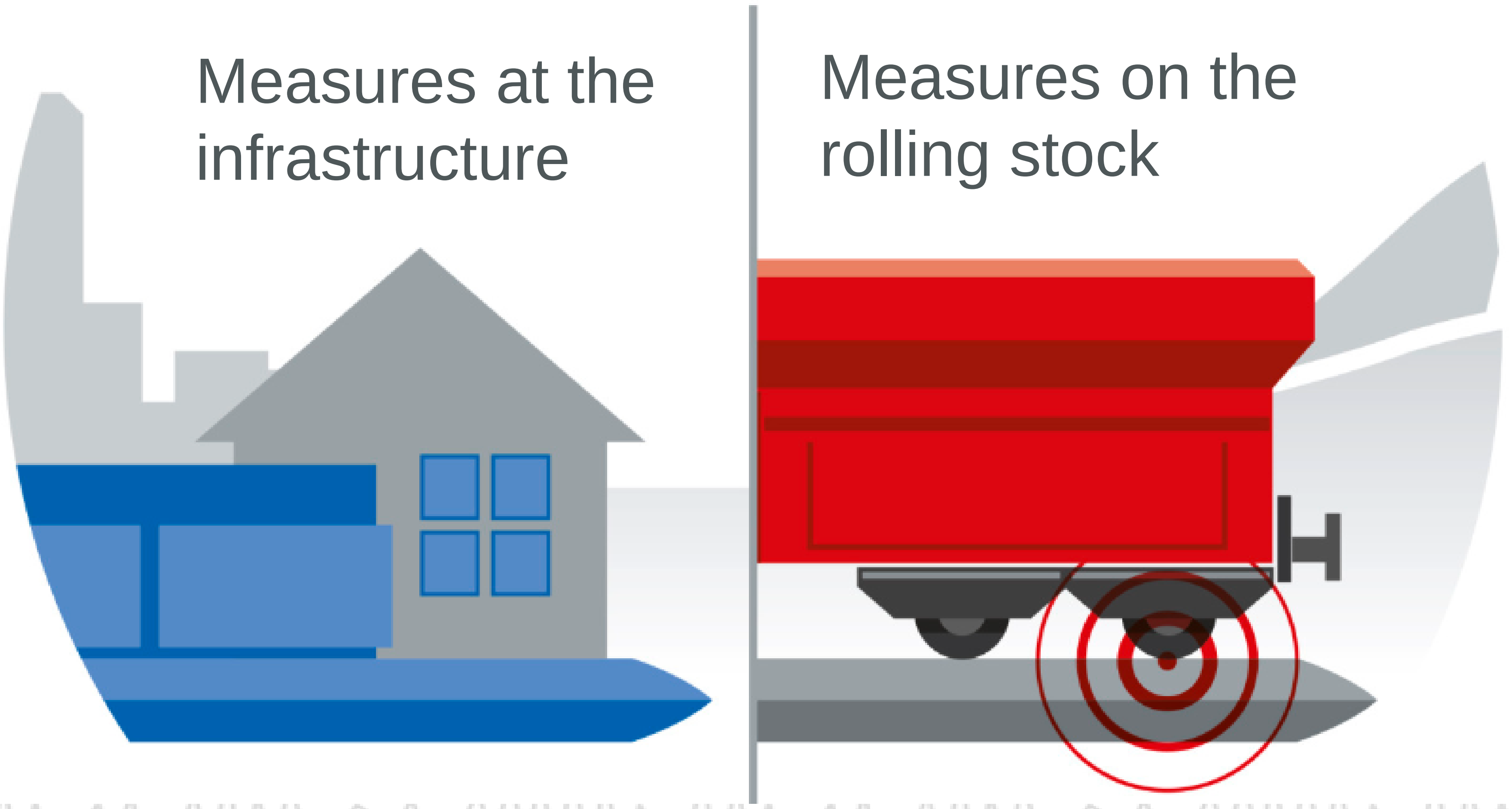


FIGURE 1-2 Illustration of the mechanism of generation of rolling noise

Source: Thompson, Railway noise and vibration, 2009




Source: DB AG, https://neubaustrecke-dresden-prag.de/en/noise-control-and-vibration/

# Acoustic Rail Roughness working group (ARR WG)

Creation in May 2022. Platform of exchange on rail roughness topics related to noise.

Around 25 participants from 14 railway companies

Activities:

- Round tables on topics of interest:
    - Overview of the members' activities
    - Measurement methods
    - etc.
- Participation in workshops
- International projects

TRAFIKVERKET SBB CFF FFS DB hs2 engine for growth NetworkRail INFRABEL Right On Track BANE NOR ProRail ÖBB adif SNCF Transport Sydney Trains banedanmark ЖЕЛЕЗНИЦЕ СРБИЈЕ

# Ideathon 14.06.2022

# Roughness after reprofiling

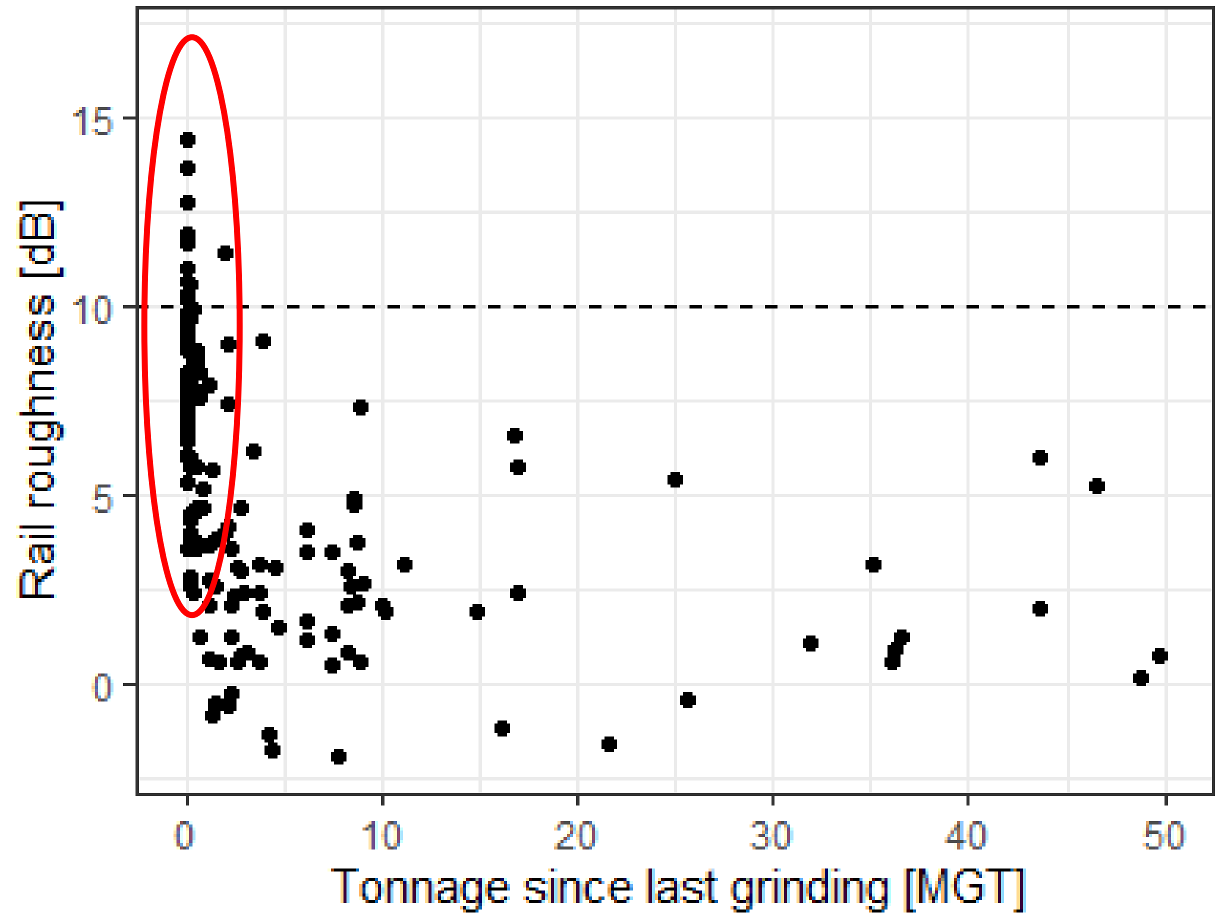



Why is this an issue ?

- **Increase of the rail roughness level** in the first weeks after reprofiling
- The periodicity of the reprofiling patterns can lead to the emergence of **tonal noise**, which can give rise to complaints from the lineside residents.
- Currently, there is no internationally recognized way to assess the acoustic performance of reprofiling.

Existing studies:

- F. Létourneaux et al., *A new metrics to assess the acoustic performance of rail grinding processes* (2016)
- J. Rothhämel et al., *Tonal noises and high-frequency oscillations of rails caused by grinding procedures* (2019)




Single value indicator of the acoustic rail roughness in function of the tonnage since last grinding. Source: Monitoring of the rail roughness in Switzerland

# Monitoring of rail roughness



Why is this necessary ?

- Better understanding of the impact of rail roughness on noise and the roughness growth mechanisms
- Optimize noise reduction strategies
- Address complaints from lineside residents
- Detect corrugated sites

The railways use a variety of systems to measure the acoustic rail roughness:

| | **On-site systems** | **On-board systems** |
|---|---|---|
| **Direct method**<br>**(measure the roughness directly)** | Straight-edge devices<br>EN 15610 | Optical systems<br>No standard |
| **Indirect method**<br>**(caculate the roughness from other measured quantities)** | Accelerometers on the rail<br>EN 16891 | Accelerometers / Microphons on the train<br>No standard |

# Opt-in proposal for submission in March 2023



## WP 1: Indicator for acoustic quality of reprofiling

Not a limit value !

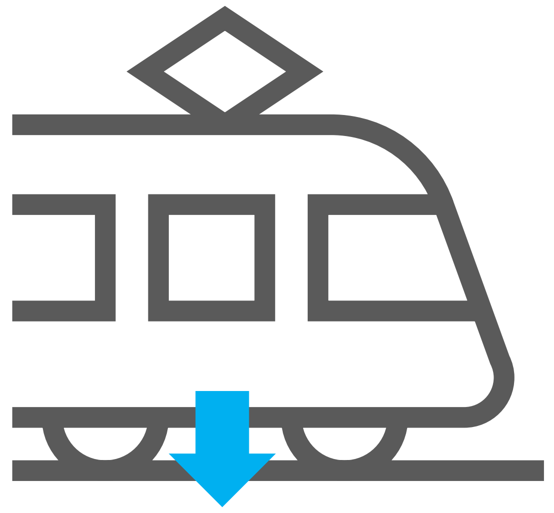
**Aims**

→ Determine a methodology to assess the acoustic performance of reprofiling

→ Facilitate the dialogue between the infrastructure managers and the grinding companies thanks to a unified evaluation of the performance.

**What needs to be done ?**

- Preliminary study: identify the situations where annoyance due to reprofiling occurs
- Relate the rail roughness to the annoyance through auralization of different situations and hearing tests
- Definition of the indicator and writing of an IRS (International Railway Solution).



## WP 2: Technical guidelines for the on-board measurement of the acoustic rail roughness

**Aims**

→ Facilitate the implementation of on-board measurement systems

→ Provide a common reference to guarantee the comparability of the measurements.

**What needs to be done ?**

- Documentation of the existing systems
- Use existing knowledge to propose a technical guideline (including measurement device, measurement method, data processing and validation of on-board measurement devices)
- Write an IRS.

# The ARR WG in an international context

NOISE

TRACK

UIC

**Noise & Vibration Sector**
UIC responsible: Pinar Yilmazer
Convenors: Jakob Oertli, Alf Ekblad
**Acoustic rail roughness WG**: Emilie Freud

Pinar Yilmazer
Mercedes Gutiérrez

**Track expert group**
UIC responsible: Mercedes
Convenor: Bernhard Knoll

**Train-track interaction group**
UIC responsible: Mercedes Gutiérrez
Convenor: David Villalmanzo Resusta

Emilie Freud
Fabien Létourneaux

Contact person
to be defined

CEN

**WG3 : Railway acoustics**
Convenor: Fabien Létourneaux

**WG50 : Monitoring and treatment of rails**
Convenor: Jürgen Reinhardt
Subgroup Reprofiling of rails: Jürgen Reinhardt

CEN / TC256: Railway Applications

# Next steps

- UIC Projects – Opt-in process
- Continue round table discussions on the following topics:
  - Roughness behavior and influence factors
  - Indicators
  - Impact of rail grinding on noise
  - Prevention of roughness increase

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**Thank you for your attention.**

# Closing Remarks

## David Villalmanzo

*UIC TTI Sector Chair*

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