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Addressing Rail Roughness in Noise Management: Insights from the UIC ACORD Project

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UIC

ACORD Acoustics of Reprofiling and Onboard Monitoring of Rail Roughness

Why Rail Roughness Matters

Railway noise is predominantly generated by rolling noise arising from wheel–rail interaction. This noise is strongly influenced by combined surface roughness, particularly in the wavelength range associated with audible frequencies (50–10,000 Hz). Its intensity is governed by three key factors:

- Noise sources associated with the rolling stock
- Mechanical properties of the wheel–track system
- Combined wheel–rail roughness over acoustically relevant wavelengths

Roughness is the most controllable factor for noise reduction

🚧 PROBLEM

- Rail reprofiling (grinding/milling) restores rail condition
- May introduce periodic roughness patterns
- Leads to increased noise and tonal, intrusive effects for communities

⚠️ GAP

- Existing standards focus on geometry, not perception
- No harmonised metric linking roughness to noise impact
- Monitoring practices are fragmented and inconsistent
- Limits comparison, benchmarking, and effective mitigation

✅ ACORD RESPONSE

- Develops a harmonised, data-driven acoustic indicator
- Combines:
  - Noise modelling (auralisation)
  - Listening tests (perception)
  - Spectral analysis
- Supports onboard monitoring

➡ Links roughness → noise → perception

Towards Acoustic-Controlled Maintenance

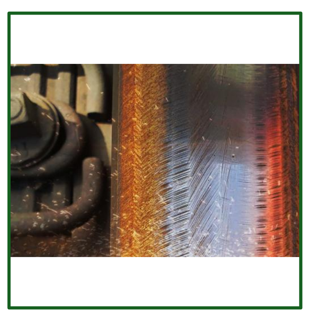
REPROFILING

- Must balance between mechanical performance and acoustic outcomes

ACOUSTIC GRINDING

- Preventive maintenance with low material removal (0.1–0.2 mm/pass)
- Applied at regular intervals
- Controls noise-relevant roughness spectrum
- Maintains stable acoustic performance over time

ACORD Project Structure

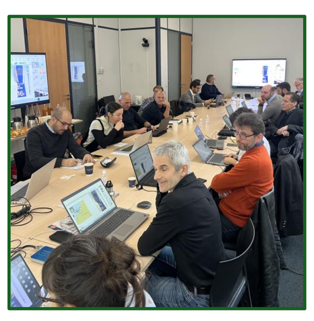


WP1 – Acoustic Quality of Reprofiling

- Develops a harmonised indicator linking grinding quality to noise
- Defines methods and operational guidelines

WP2 – Onboard Monitoring

- Establishes guidelines for network-wide monitoring
- Enables scalable, non-intrusive measurement



Collaborative Framework

- Data sharing, expert input, and literature review
- Supports evidence-based, harmonised solutions

From Roughness Data to an Operational Acoustic Indicator

How to define an indicator for the acoustic quality of rail reprofiling?

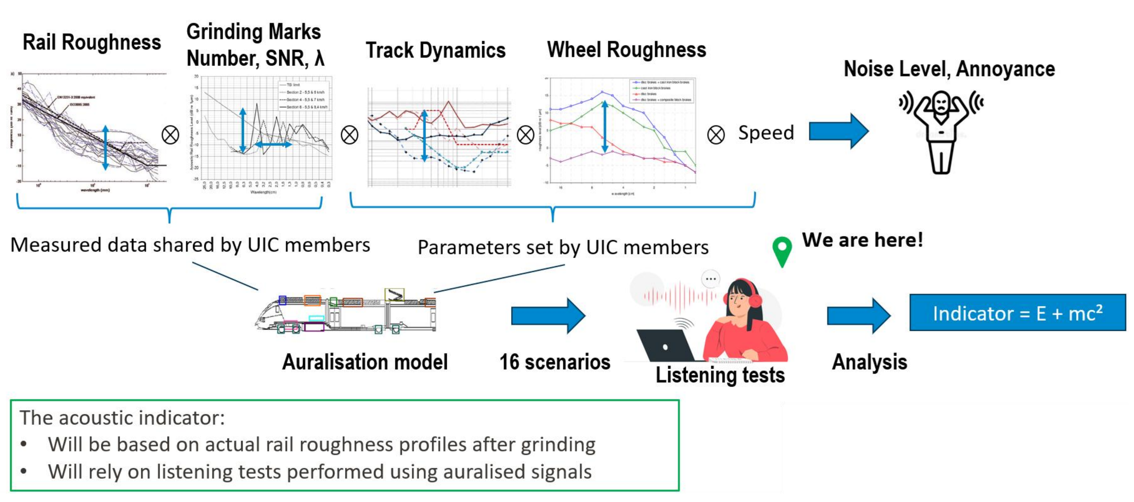


Figure 1: A Method for Defining Acoustic Quality in Rail Reprofiling

Roughness Inputs

- Measured + synthesised wheel–rail roughness
- Frequency range: 50–10,000 Hz
- Metadata: grinding type, traffic load, time since reprofiling, measurement system.

Auralisation Model

- Combines wheel–track parameters with roughness data
- Simulates **before/after** reprofiling pass-by noise
- Enables controlled comparison of surface condition

Listening Tests

- Use simulated pass-by noise samples
- Assess **annoyance, tonality, acoustic quality**
- Links between roughness features and perception

Indicator Design

- Identify **acoustically relevant** roughness features
- Integrate modelling + perceptual results
- Develop a **harmonised acoustic indicator**

Operational Use

- Plan + optimise grinding strategies
- Validate reprofiling quality
- Compatible with **direct** and **onboard** monitoring

Auralisation and Listening Tests

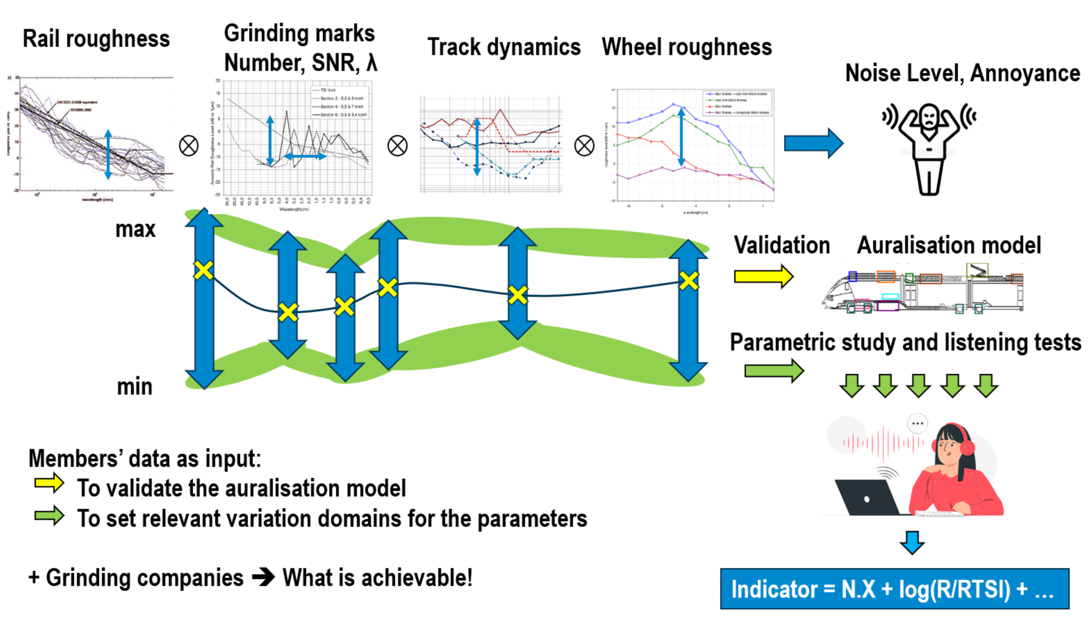


Figure 2: Integrated Approach to Acoustic Quality Assessment in Rail Reprofiling

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Further details: UIC ACORD State-of-the-Art Report

Roughness Monitoring Systems: Direct and Indirect approaches

European practices are highly variable across systems and data approaches.

ACORD addresses monitoring as both a technical and organisational challenge.

SBB CFF FFS, INFRABEL, ÖBB, SNCF, Ferrovie Italiane, Network Rail, BANE NOR, ProRail, HS2, DB, Infraestruturas de Portugal, BCRRE, Trafikverket, Sydney Trains

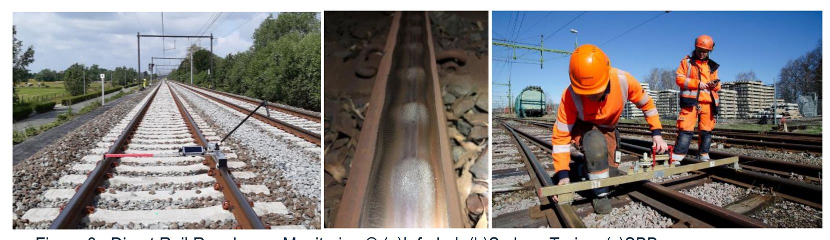

Figure 3: Direct Rail Roughness Monitoring © (a)Infrabel, (b)Sydney Trains, (c)SBB

	Direct monitoring	Indirect monitoring
Typical system	Trolley or fixed device using displacement / acceleration measurements	Onboard microphones, accelerometers or laser-based systems
Main strength	Absolute and traceable spectra under controlled conditions	Network-wide coverage without interrupting traffic
Main limitation	Requires track access and longer inspection time	Results depend on wheel condition, speed and track state
Best suited to	Reference measurements, acceptance and validation	Screening, hotspot detection and maintenance planning
Standard alignment	Closest to EN 15610 methodology	No current system fully complies with EN 15610

Figure 4: Indirect Rail Roughness Monitoring © (a)Infrabel, (b)BaneDanmark & Sweco

Examples Across ACORD Partners

🔵 Network-wide monitoring

- BaneDanmark – On-board monitoring for large-scale assessment
- DB – Acoustic train for compliance monitoring

🟢 Combined approaches

- Infrabel – Direct + indirect for mapping and R&D
- ÖBB – Integrated on-board + validation systems

🟡 Targeted / specialised systems

- IP – Corrugation and grinding validation
- ProRail / Infraspeed – High-speed and selective monitoring

🟣 Limited / emerging monitoring

- SBB – Direct measurements, grinding strategy
- SNCF – R&D-driven measurements
- Trafikverket – Geometry-focused monitoring
- Network Rail – Geometry + limited acoustic
- Stockholm Metro – Continuous IoT monitoring

Challenges for Deployment

1. **Fragmented practices** → limited comparability
2. **Temporary acoustic gains** → roughness regrows
3. **Uncertain drivers** → weak life-cycle predictability
4. **Onboard limits** → affected by wheel, speed, track
5. **No common target** → standards lack acoustic alignment

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