Mitigating Transit Rolling Noise at Source

Briony Croft, SLR Consulting (Canada)

Presentation Overview

Transit noise issues originating in the wheel/rail interface

Focus on rolling noise (common issue, in car and outside)

What factors affect rolling noise emissions?

What are the mitigation options?

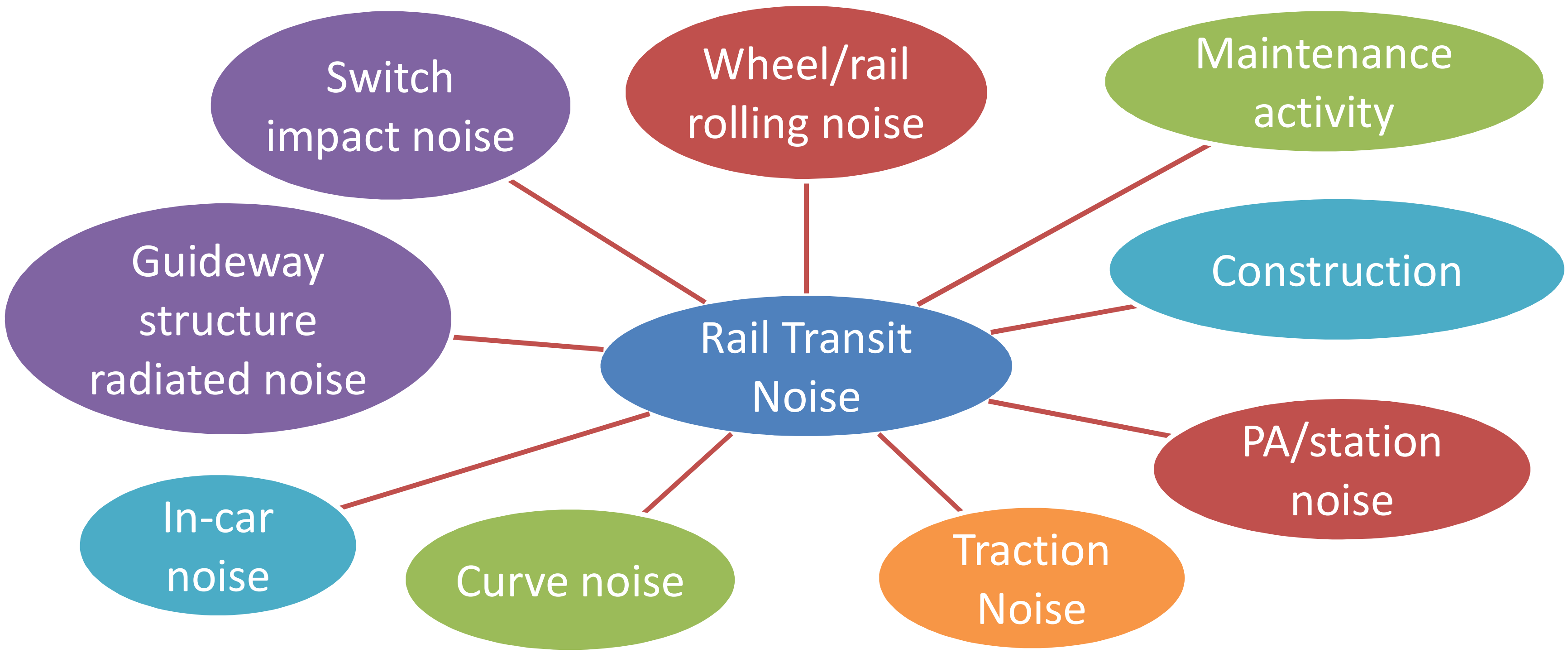
Case studies

Noise Mitigation Options

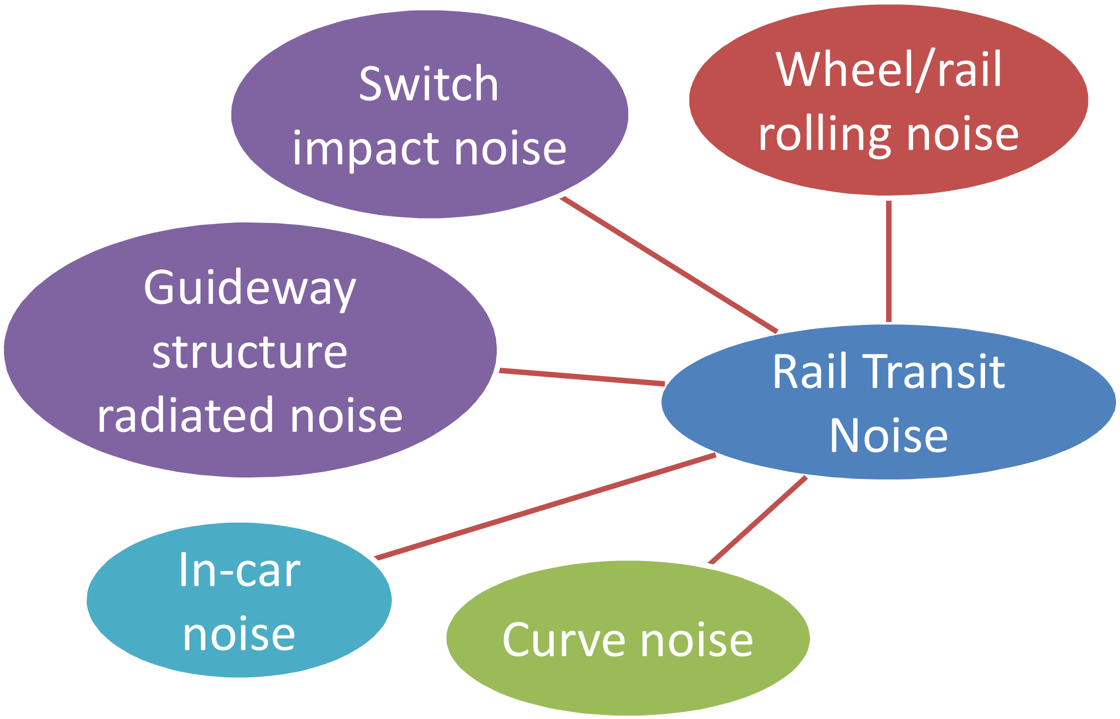
- At source (wheel/rail interface)
- Along propagation path (barriers)
- At receiver (upgraded facades / glazing / mechanical ventilation)

At-source is usually preferable

Rail Transit Noise Issues



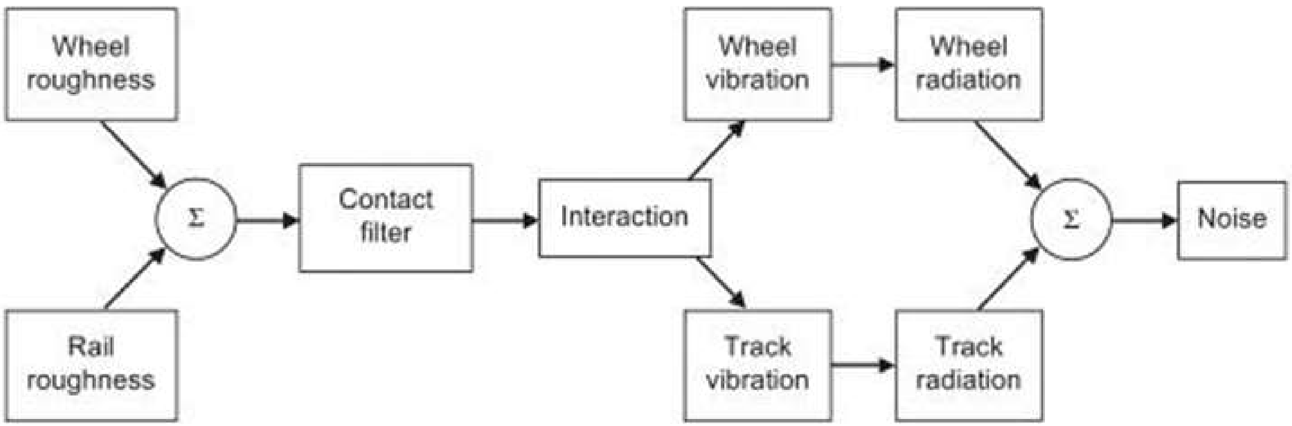
Wheel Rail Interface Issues

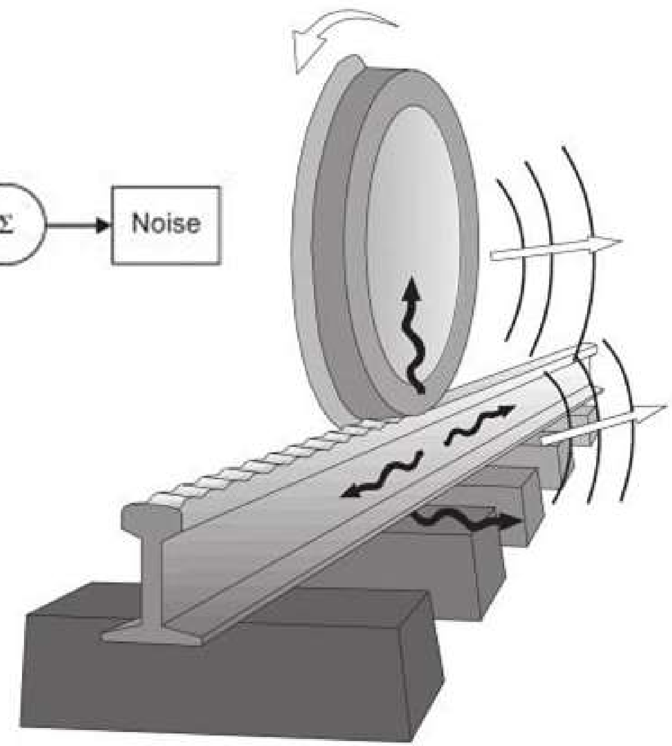


Many rail transit noise issues originate in the wheel-rail interface

An understanding of wheel rail interaction is key to mitigating all these issues at source

Rolling Noise





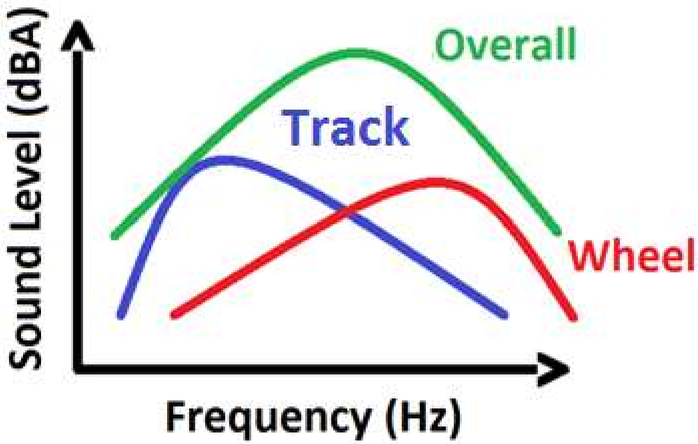
Figures reproduced from *Railway Noise and Vibration Mechanisms, Modelling and Means of Control*
David Thompson, 2009

Rolling Noise Example

Contributors to Rolling Noise

Noise is radiated from the wheels and the track (rails, ties)

The combined roughness of the wheels and rails directly influences overall rolling noise

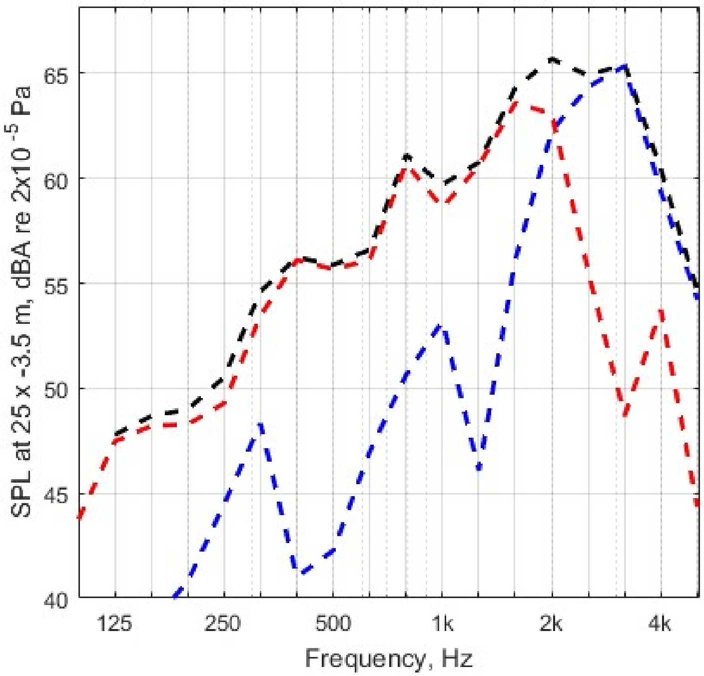


The contribution of the wheel and track to the overall noise level depends on the design

Rolling noise is speed-proportional

Calculated Noise Level (dBA) vs Frequency (Hz)

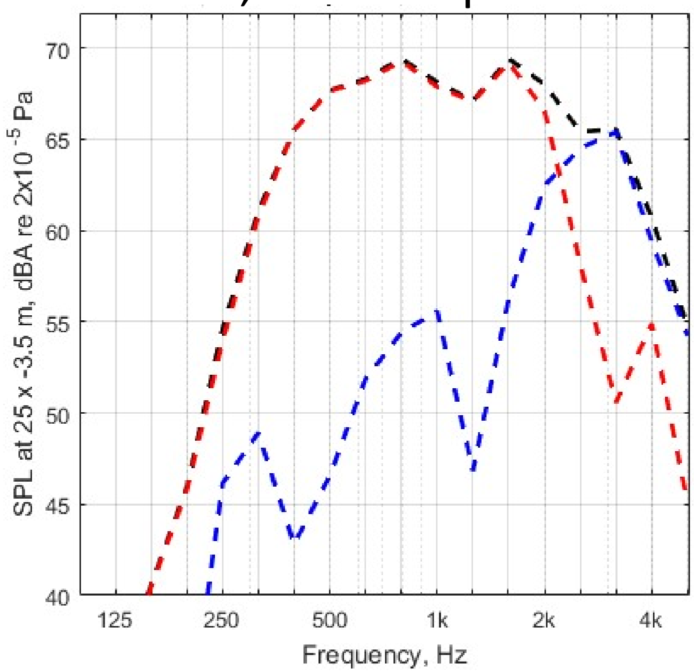
Ballast and tie



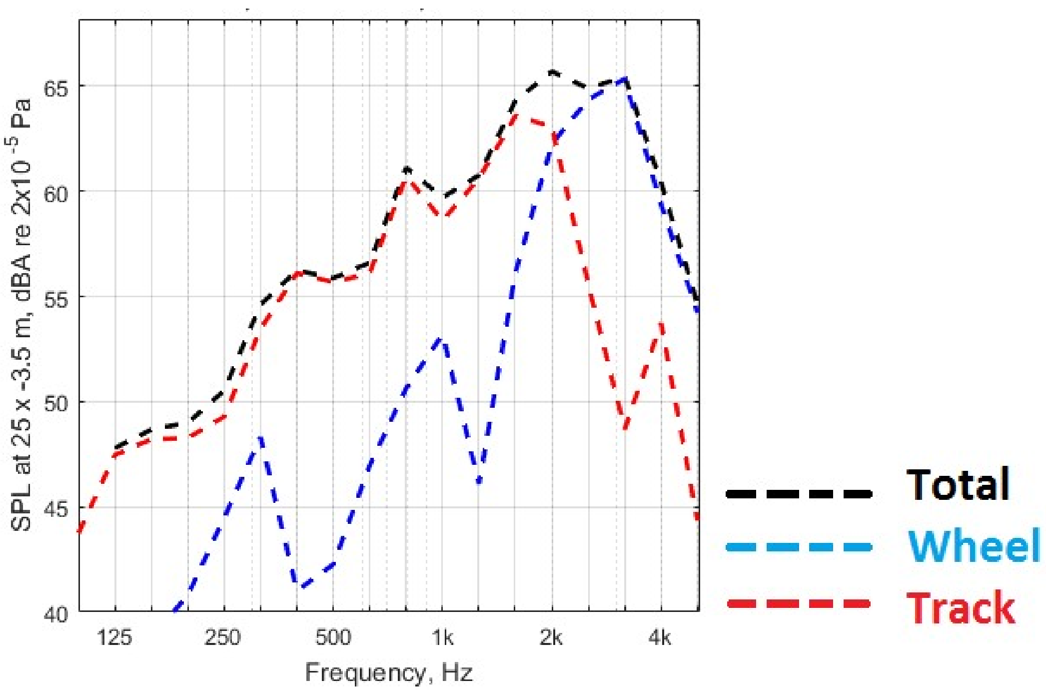
"STARDAMP" software. Both with same wheel design, 80 kph

Total
Wheel
Track

Slab, soft baseplates

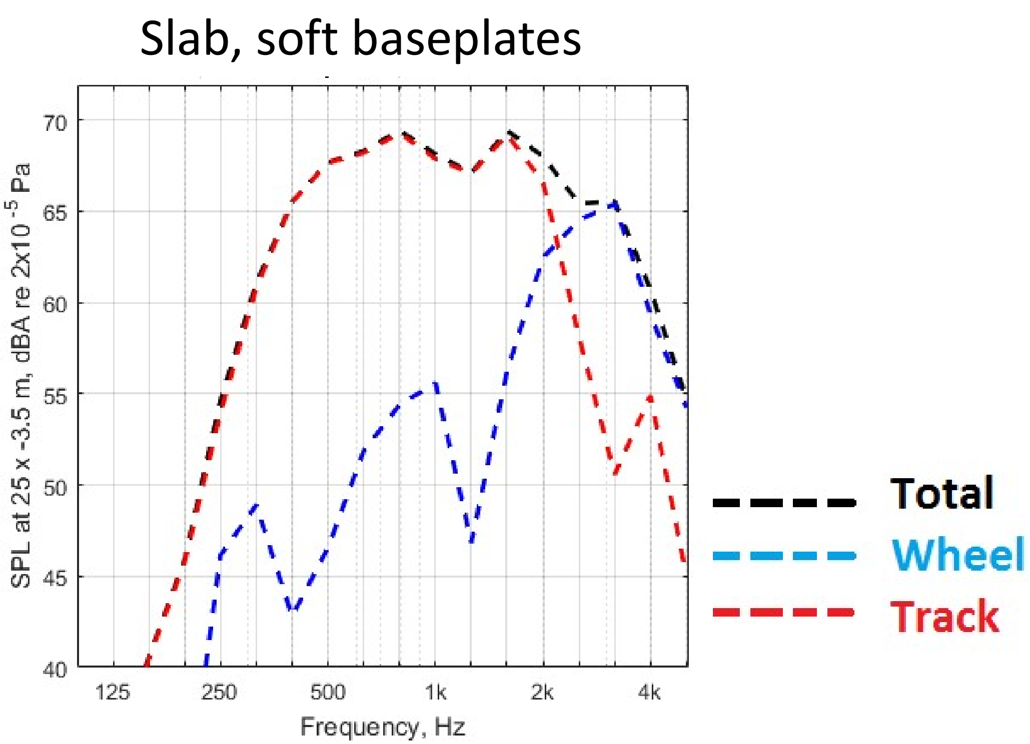


Ballast and tie contribution of components



- Both wheels and track contribute to the total
- Wheels produce more noise at higher frequencies > 2 kHz
- Track dominates < 2 kHz
- Reducing total noise would require mitigation of both wheels and track, or reducing roughness

Slab with soft baseplates contribution of components



- The track (rails) dominate the total A-weighted noise level
- Reducing total noise would require mitigation of only the track, or reducing roughness

Rolling Noise Summary of Factors

- Combined roughness of wheels and rails
- Track component selection: slab typically noisier than ballast
  softer rail pads/baseplates noisier
- Wheel shape and size: smaller wheels tend to be quieter
- Train speed: faster = noisier

Rolling Noise Source Mitigation Options

- Reduce combined roughness of wheels and rails
- Track component selection or rail dampers

Case Studies

- Wheel/rolling stock design or wheel dampers
- Reduce speed – not a realistic option in most cases

Case Study - Acoustic Roughness

Questions: How important is roughness?

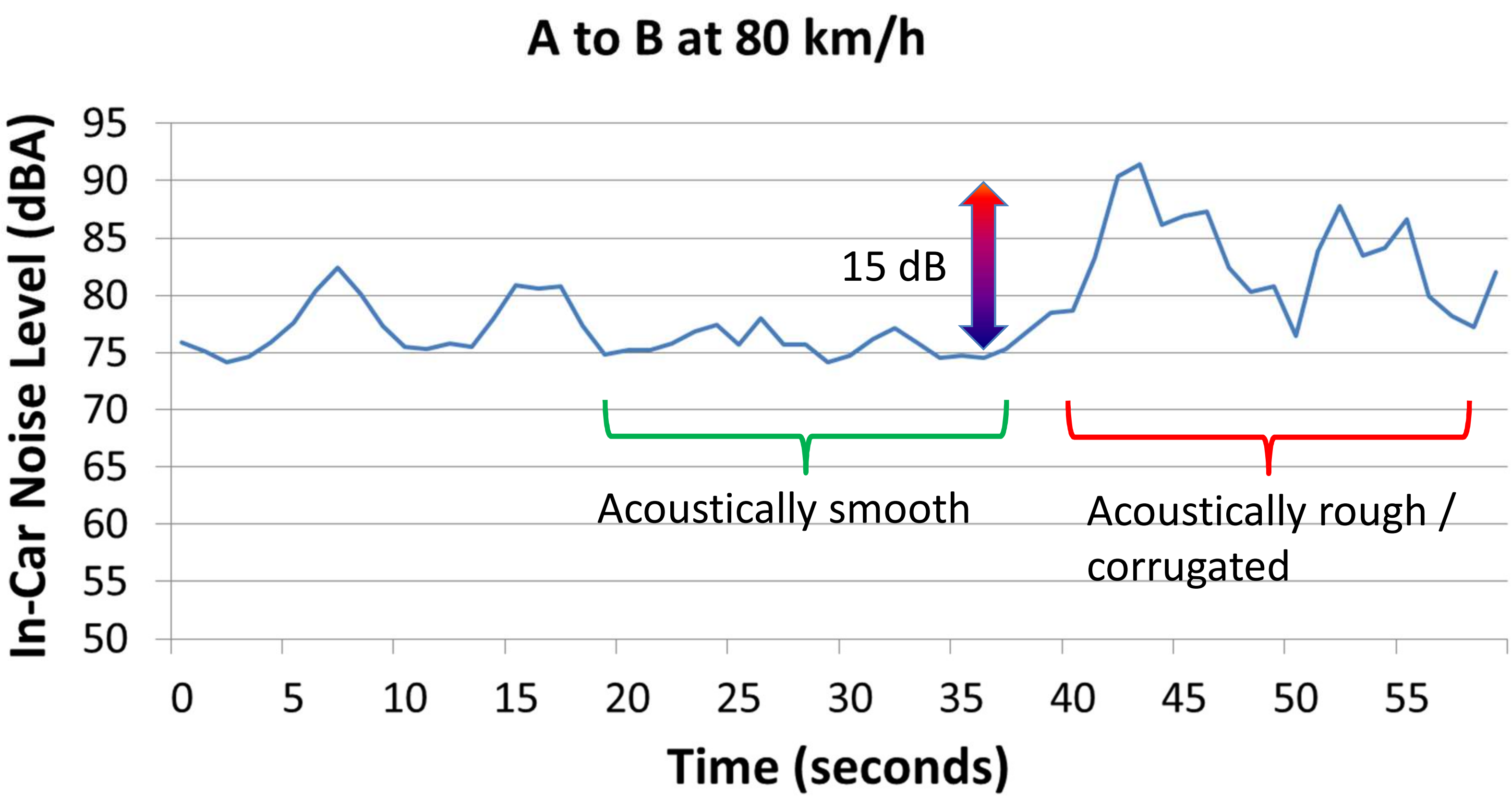
How much difference in noise are we talking?

Example: In-car noise level (no passengers)

Constant speed surface track (80 km/h)

No track features such as switches

Only variable is rail roughness / track condition

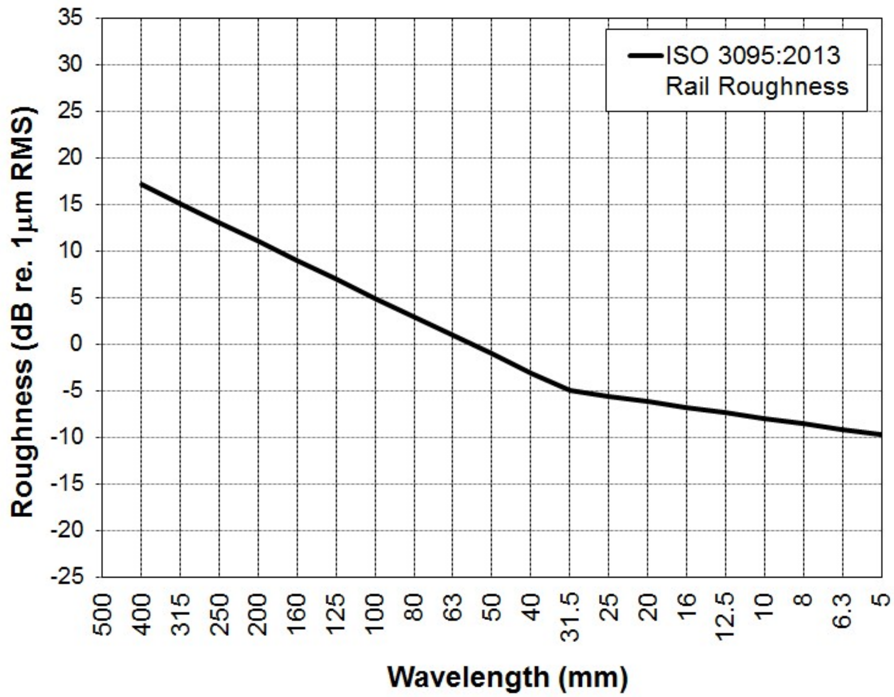

A to B at 80 km/h
In-Car Noise Level (dBA)
95
90
85
80
75
70
65
60
55
50
15 dB
Acoustically smooth
Acoustically rough /
corrugated
0
5
10
15
20
25
30
35
40
45
50
55
Time (seconds)

Rail Acoustic Roughness Measurement

Standard:

EN 15610 Railway applications – Noise emission – Rail Roughness measurement related to rolling noise generation

Rail Acoustic Roughness Target



ISO 3095:2013

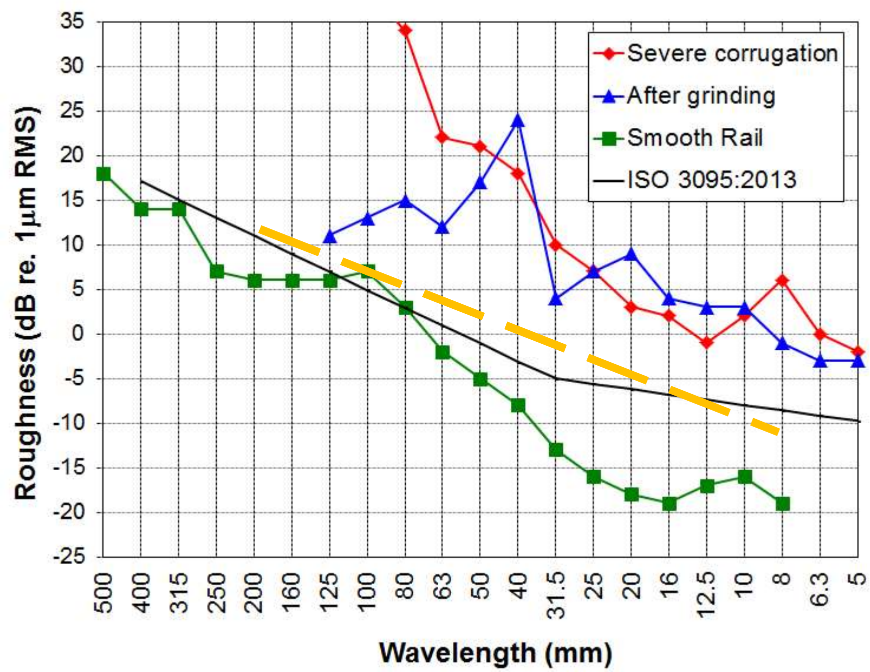
Rails in very good acoustic condition

ISO 3095 vs DIN 13231-3

Wavelength Range (mm)	10 to 30	30 to 100	100 to 300	300 to 1000
DIN 13231-3 Limit of peak-to-peak (µm)	10	10	15	75
ISO 3095 equivalent Limit of peak-to-peak (µm)	2	4	15	

"Acoustic" roughness targets for short wavelengths are much more stringent than regular maintenance grinding specifications

Measured Roughness Examples



Rail roughness can vary widely

Disc braked wheel typical roughness (this can also vary)

Optimum to minimise noise: rail ≈ wheel, both as low as possible

Roughness and Noise

- Rougher rails increase noise
- Grinding treats symptom not cause
- Maintenance grinding can increase acoustic roughness and noise
- If corrugation is not completely removed, it may return rapidly
- Controlling roughness is a form of noise control at source

Roughness Management Options

- Component selection (maybe, in special cases)
- Friction management
  - Top of rail friction modifiers slow corrugation growth
- Acoustic grinding vs maintenance grinding
  - Tools available (grinding/milling, rotating/oscillating stones)
  - Emphasis on surface finish rather than material removed
  - More stringent specifications
  - Roughness measurement for compliance

Case Studies - Rail Dampers

Questions: What is a rail damper?
Why don't they always work?
Which situations do they work best in?
How much difference in noise are we talking?

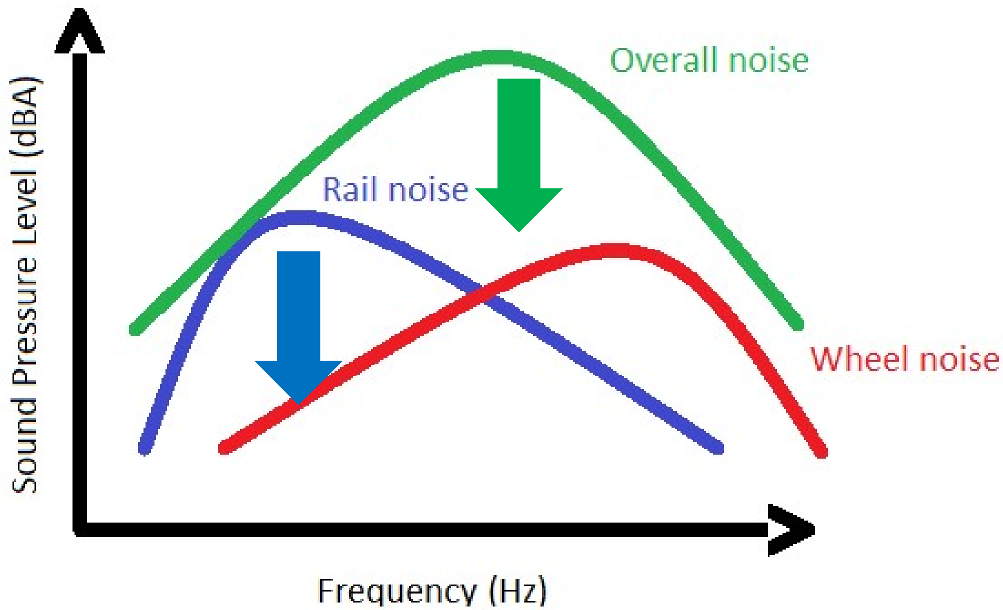
Examples: Four different rail damper trials in Australia

- Different train / wheel types
- Different track types

What is a rail damper?

- Concept developed in EU funded Silent Track project ‘96-’99
- Tuned mass-spring-damping system
- Attached to rail between regular fasteners
- Reduces the length of rail that vibrates under a train, reducing rail contribution to overall noise

The aim of a rail damper



To reduce overall noise by reducing the rail contribution only

(no change to wheel noise)

Why don't rail dampers always work?

- Some track designs are already "low noise"
  - Stiff rail pads, high vibration decay along rails
  - Rail dampers make no difference if rail noise is already low
- Some wheel designs are noisy
  - Wheel noise sometimes dominates overall levels
  - Rail dampers make no difference to wheel noise

Which situations are least likely to benefit from rail dampers?

– Embedded rails
– Squeal and flanging noise issues
– Stiff rail pads
– Larger, noisy wheel shapes
– Mixed freight and passenger traffic
– Ballasted track (but it depends…)

Which situations have potential for effective treatment?

- Slab track
- Systems with soft rail pads or baseplate fasteners
- Relatively small wheels
- Rolling noise is the dominant issue
- In-car noise in tunnels

Trial No. 1

- Sydney
- Ballasted track
- Very stiff rail pads (dynamic stiffness 800MN/m)
- 940 mm wheel
- 0-1 dB benefit

Trial No. 2

- Sydney
- Dive and tunnel, slab track
- Soft baseplates (dynamic stiffness ~30MN/m)
- 940 mm wheel
- 4 dB benefit

Trial No. 3

- Perth
- Ballasted track trial
- Moderately stiff rail pads (dynamic stiffness 100 MN/m)
- 840 mm wheel
- 4-5 dB benefit

Trial No. 4

- Perth
- Slab track trial in tunnel
- Very soft supports (dynamic stiffness ~8 MN/m)
- 840 mm wheel
- 8 dB benefit (in car)

Summary: rolling noise mitigation at source

Understand the contributing factors to plan effective noise mitigation.

What is the rail roughness now? Can it be improved?

Is the wheel or the rail noisier? Which is the target?