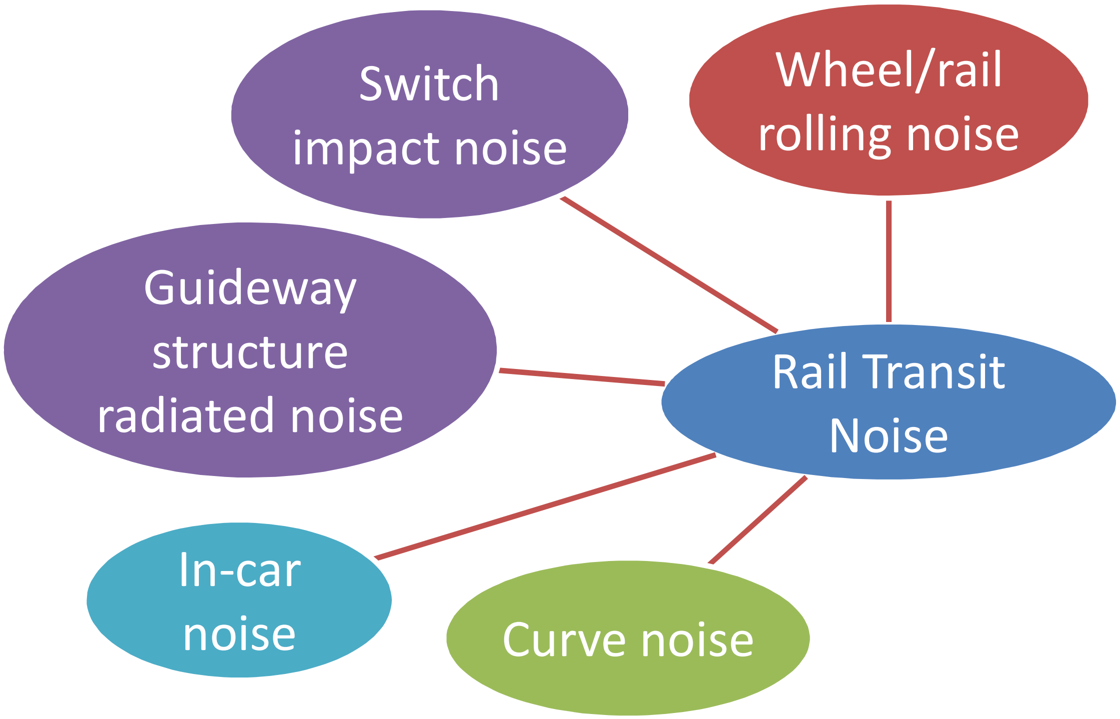
Rail dampers – transit noise reduction outcomes

Case studies from Ottawa and Vancouver

Presentation Overview

1. **Wheel/rail interface and rail transit noise issues**
2. **Rolling noise mitigation options**
3. **Vancouver rail damper trial and optimization efforts**
4. **Ottawa rail damper implementation outcomes**

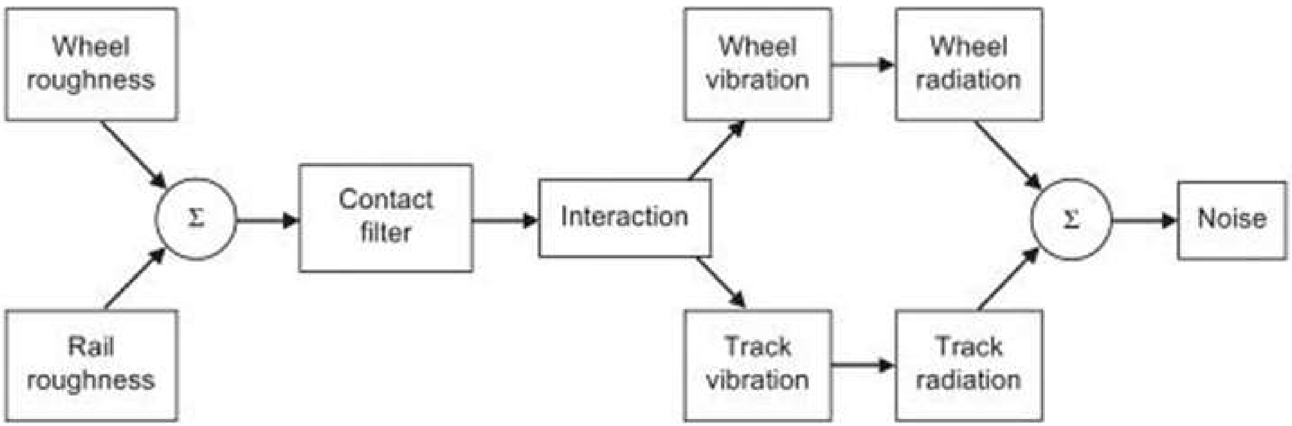
Wheel Rail Interface Noise Issues

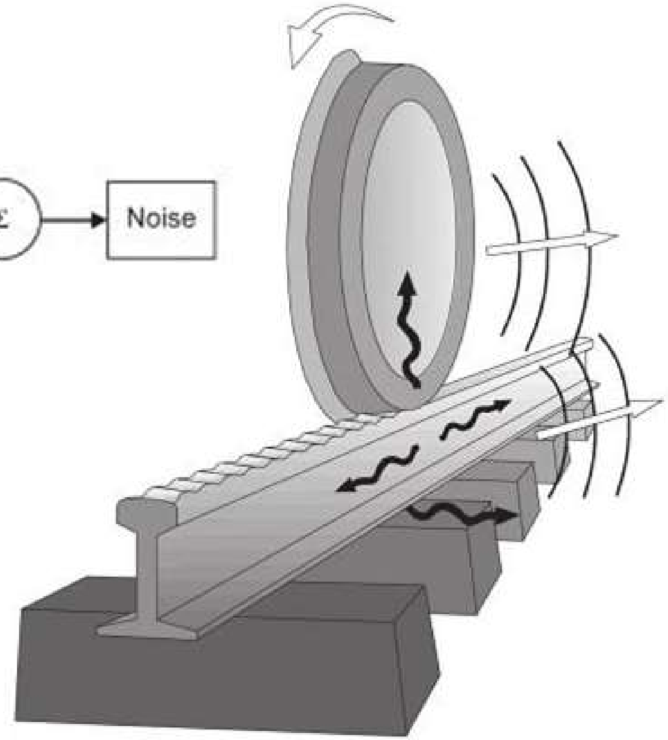


Many rail transit noise issues originate in the wheel-rail interface

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

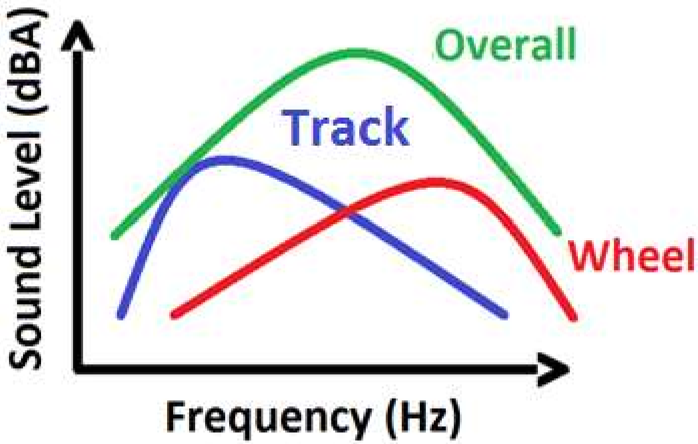
Contributors to Rolling Noise

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

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

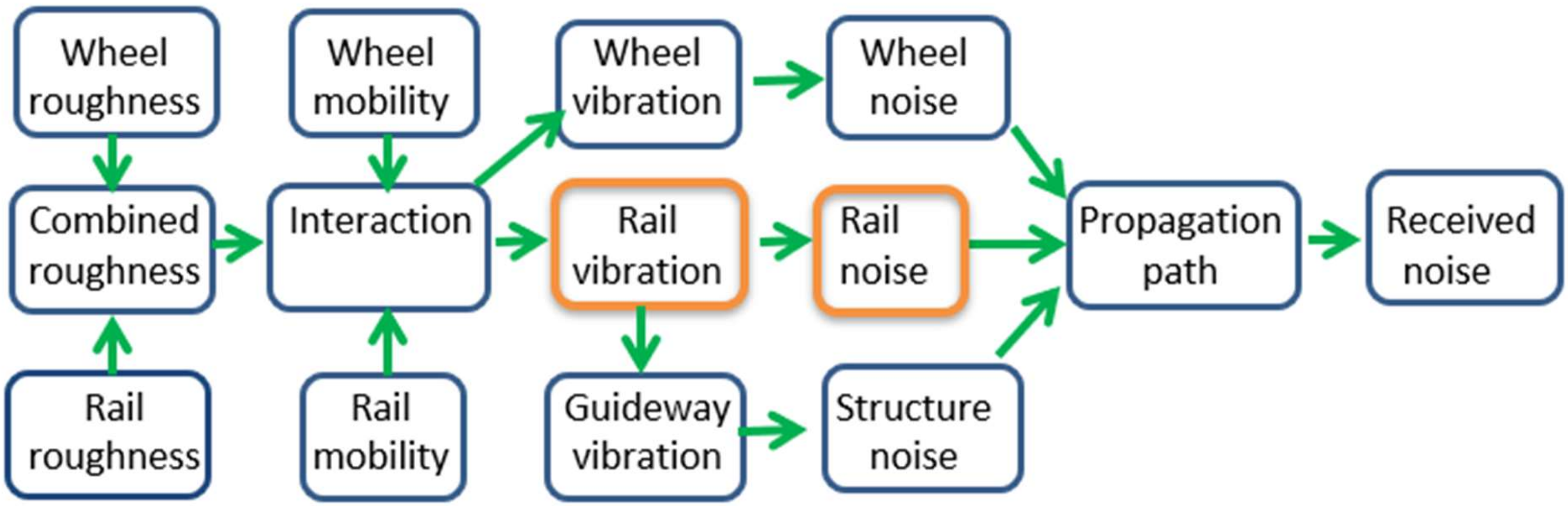
The contribution of the wheel and track to the overall noise level depends on the design

Rolling noise is speed-proportional



Rolling Noise Example

Roughness input	Wheel/rail interaction	Vibration of components	Noise radiation	Noise propagation	Noise at receiver

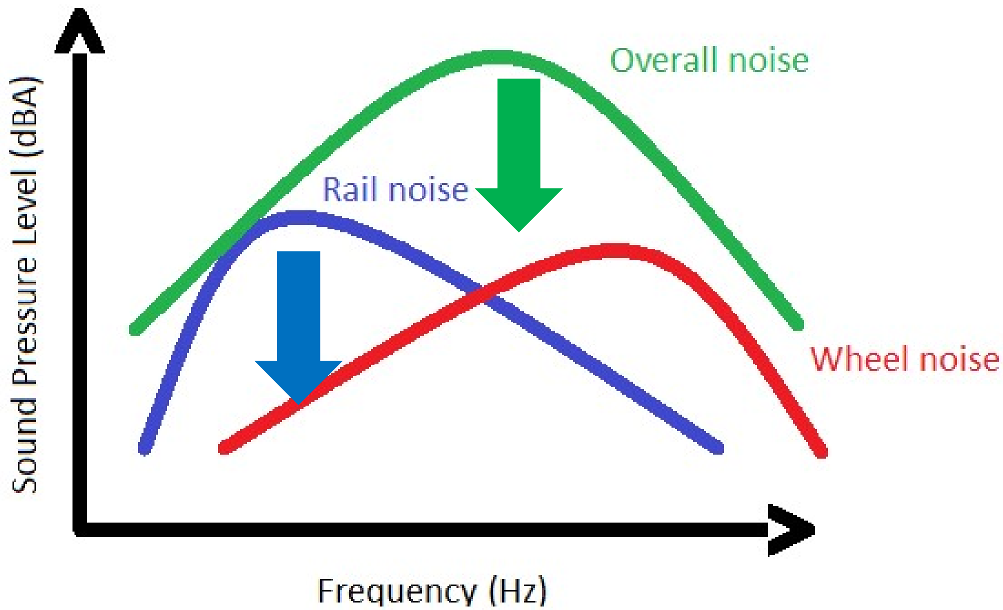


Reduce roughness	Change component design	Add damping	Barriers, absorption	Façade treatment

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)

Rail damper limitations

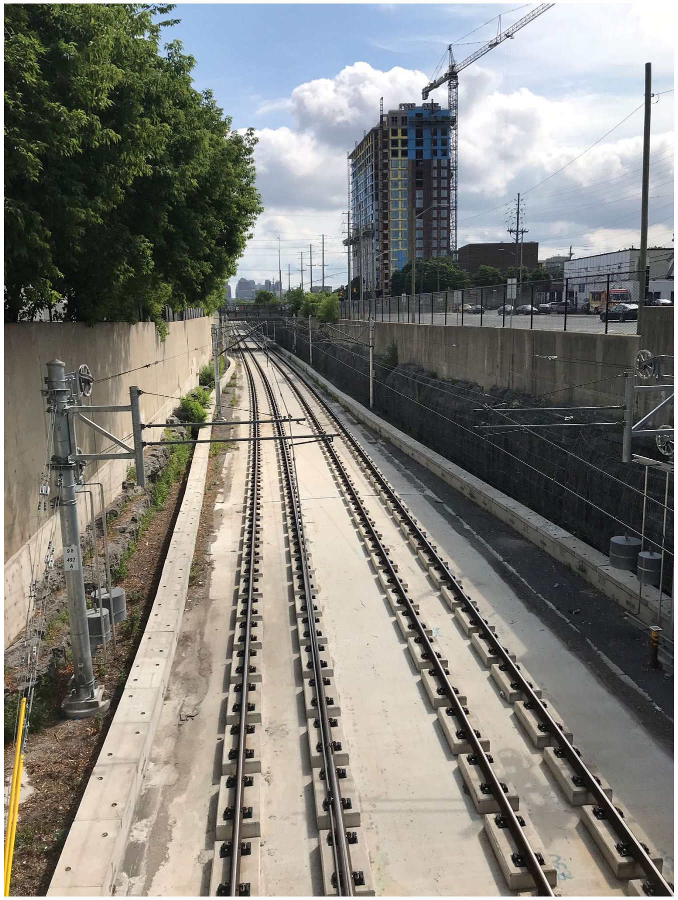
- Some track designs are already “low noise”
  - Stiff rail pads, high vibration decay along rails
  - Rail dampers make no difference if rail noise is already low
- Some wheel designs are noisy
  - Wheel noise sometimes dominates overall levels
  - Rail dampers make no difference to wheel noise

Which situations have potential for effective treatment?

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

Vancouver

Ottawa

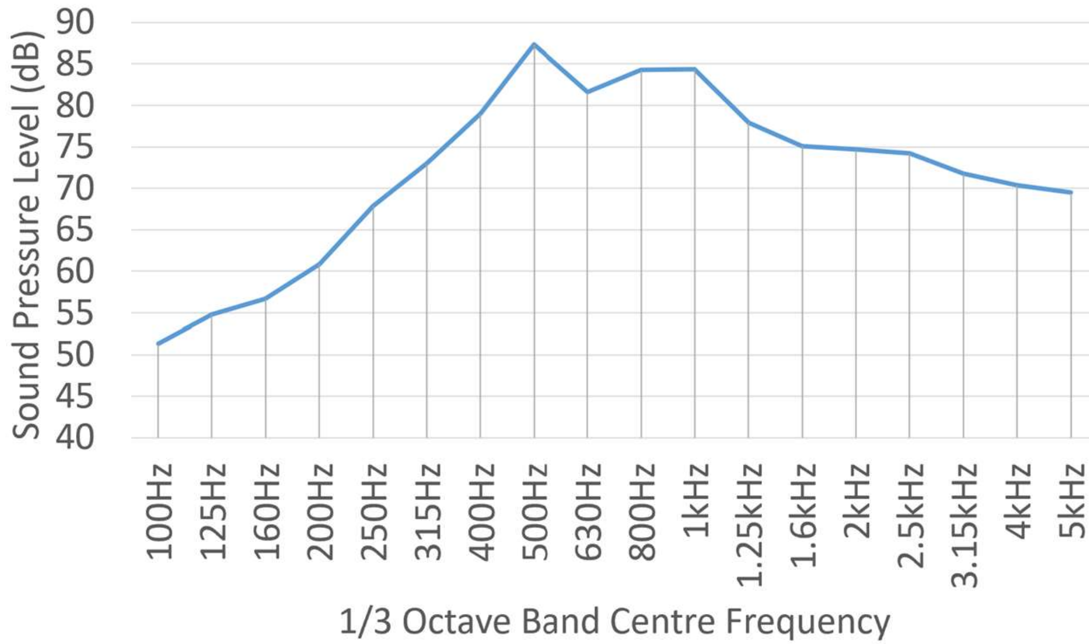


System parameters

	Vancouver	Ottawa
Track type	Slab (elevated guideway)	Slab (trench)
Rail	AREMA 115RE	AREMA 115RE
Rail fastener / baseplate	Lord	Delkor Alt 1
Fastener spacing	1 m (0.5 m on curves) (39")	0.75 m (30")
Nominal dynamic stiffness	25 kN/mm (145 kips/in)	25-50 kN/mm
Wheel description	Monobloc	Resilient
Wheel diameter	471 / 585 mm (18.5"/23")	640 mm (25")
Operating speed	80 km/h (50mph)	50-70 km/h (30-45mph)

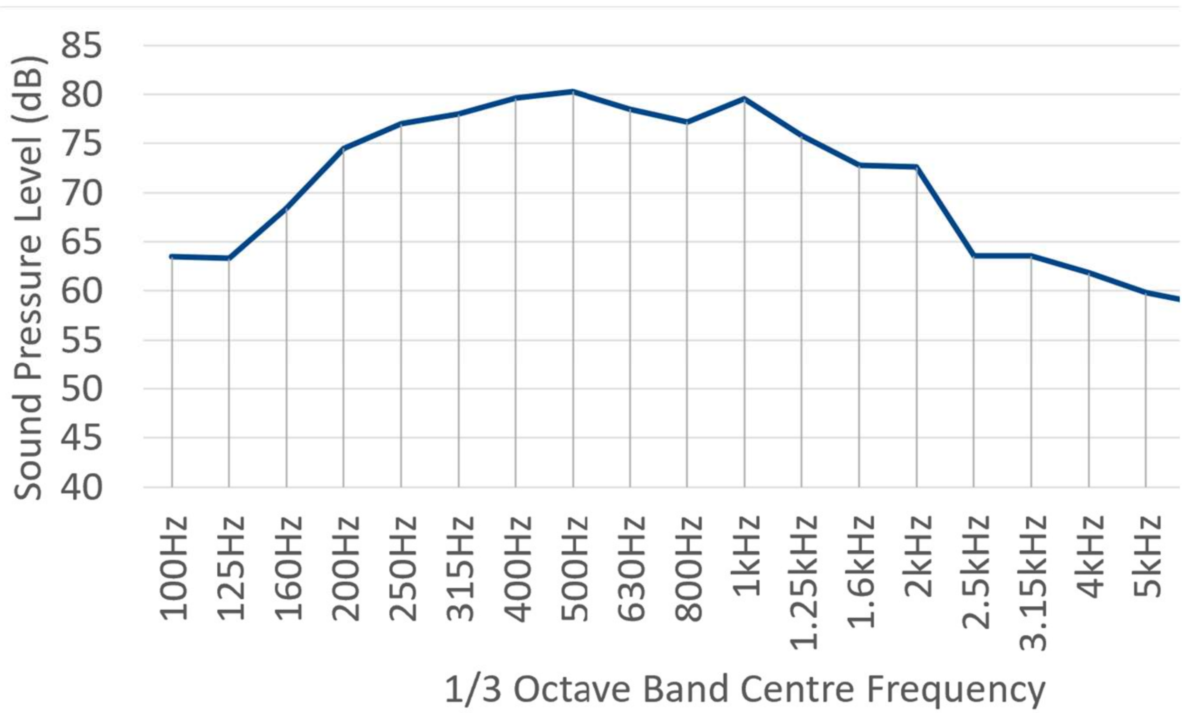
Passby Noise Spectra - Vancouver

- Corrugation peak at 500 Hz
- Speed 80 km/h
- 500 to 1000 Hz dominant



Passby Noise Spectra - Ottawa

- Not corrugated
- Speed 50-70 km/h
- 400 to 1000 Hz dominant

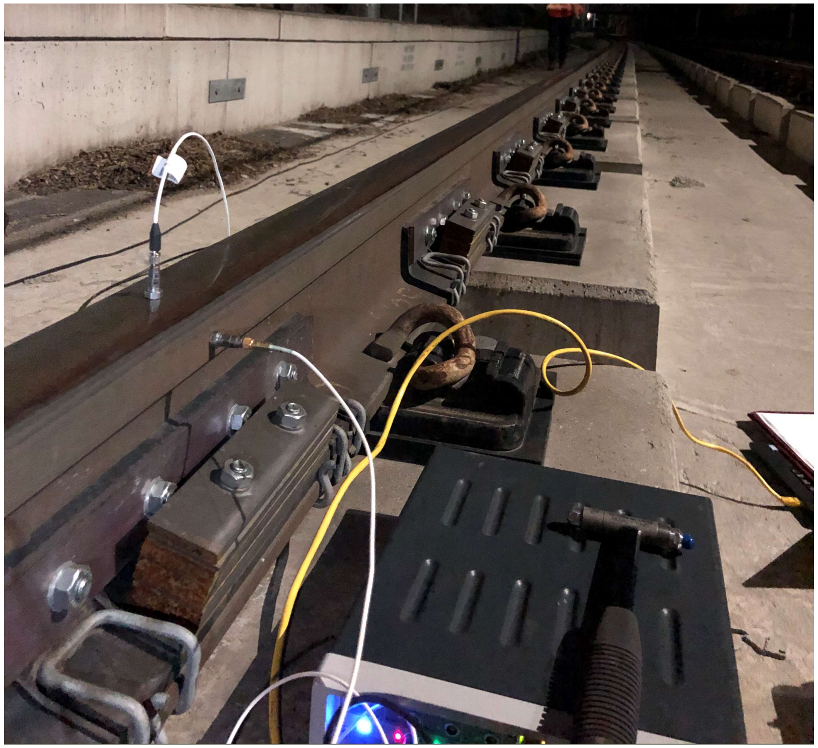


Measuring Rail Damper Effect

- Direct passby noise reduction (with and without dampers)
- Track Decay Rate (TDR)
  - *EN 15461:2008+A1:2010 Railway applications – Noise emission – Characterisation of the dynamic properties of track sections for pass by noise measurements*.
  - Vertical TDR is closely related to railway rolling noise.
  - A lower vertical TDR means that the rail is relatively free to vibrate along its length, resulting in higher noise emissions than from tracks with lower vertical TDR

Direct Noise Measurements

Ottawa dampers and TDR test



Vancouver damper configurations

Same damper (400mm long) installed 1 or 2 dampers per metre of rail

More Vancouver configurations

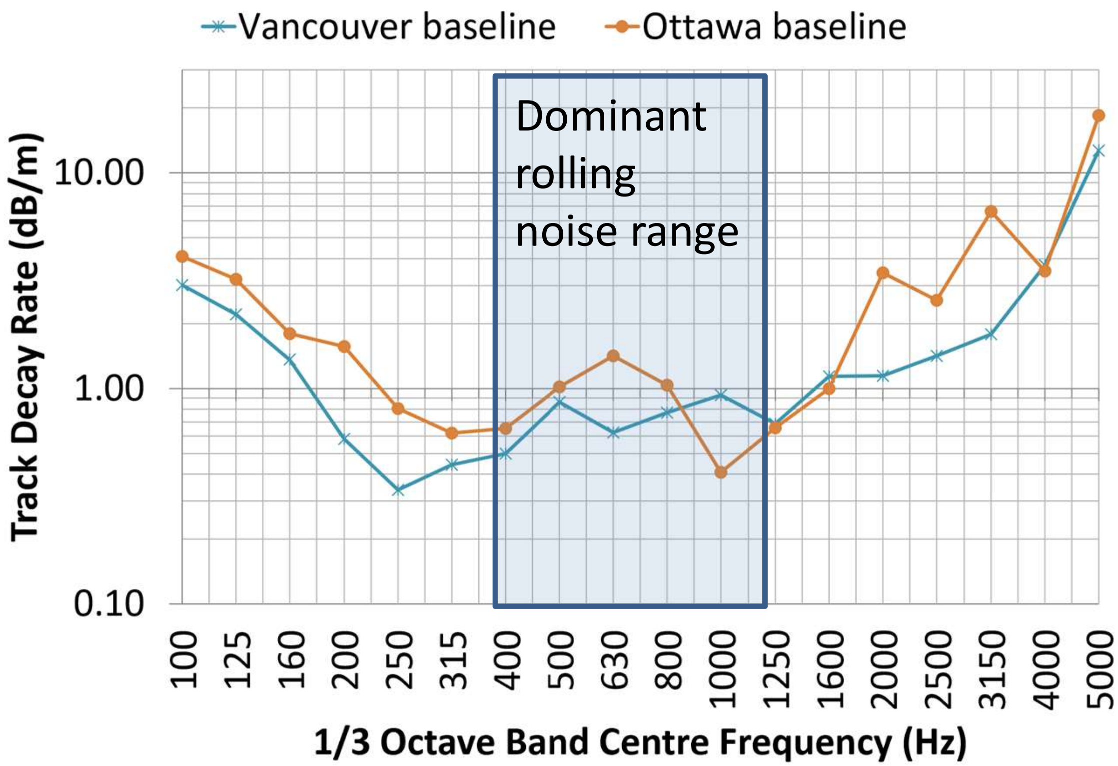
Two trial damper designs (300mm long) for areas with 500 mm fastener spacing

Measured Undamped Vertical TDRs

Vertical TDRs typical of slab tracks, low from ~250Hz to 1600Hz

Low frequency effects due to very cold Ottawa temps (-12˚C / 10 F)

Other differences due to different baseplate fastener types

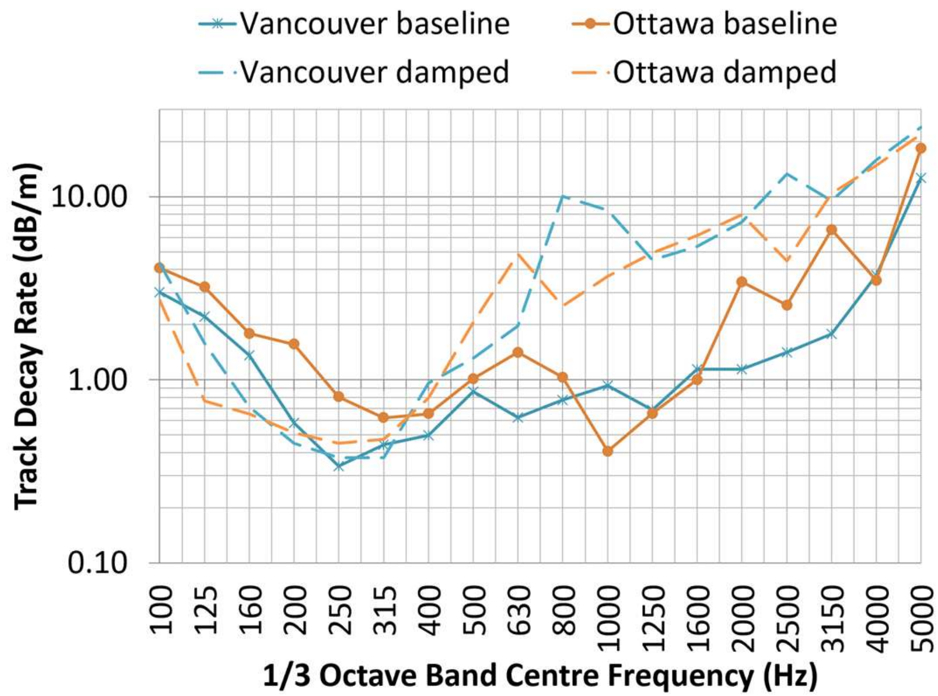


Rail Damper Effect on TDR

Both locations show increased vertical TDR at key noise frequencies with rail dampers

Note Ottawa vertical TDR increased at very low frequencies (temp effects)

Note different damper designs and fastener spacing



Vancouver trial site

Measured Noise Effects - Vancouver

Scenario	Noise Reduction
Supplier A, 400mm design, 1 damper/m of rail (in tunnel, noise in car)	4 dBA
Supplier A, 400mm design, 2 dampers/m of rail	4-6 dBA
Supplier A, 300mm design, 2 dampers/m of rail	2 dBA
Supplier B, 300mm design, 2 dampers/m of rail	1.5 dBA

Maximizing damper size / mass seems important to get best result

Areas with 0.5m fastener spacing unable to be treated effectively (space constraint)

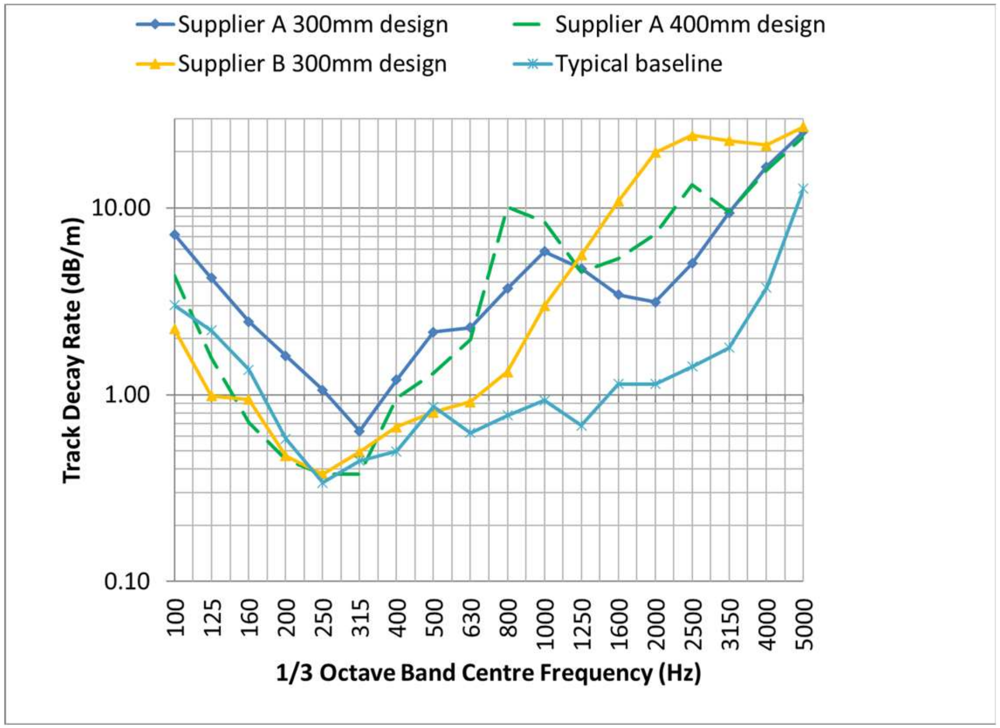
Damper tuning / matching to dominant noise important

Vancouver damped TDR comparison

All results are for two dampers per 1m of rail configurations

Different designs have clearly different vertical TDR results

Mass / tuning effects seen particularly in 400-1000 Hz bands that are critical for transit noise in Vancouver



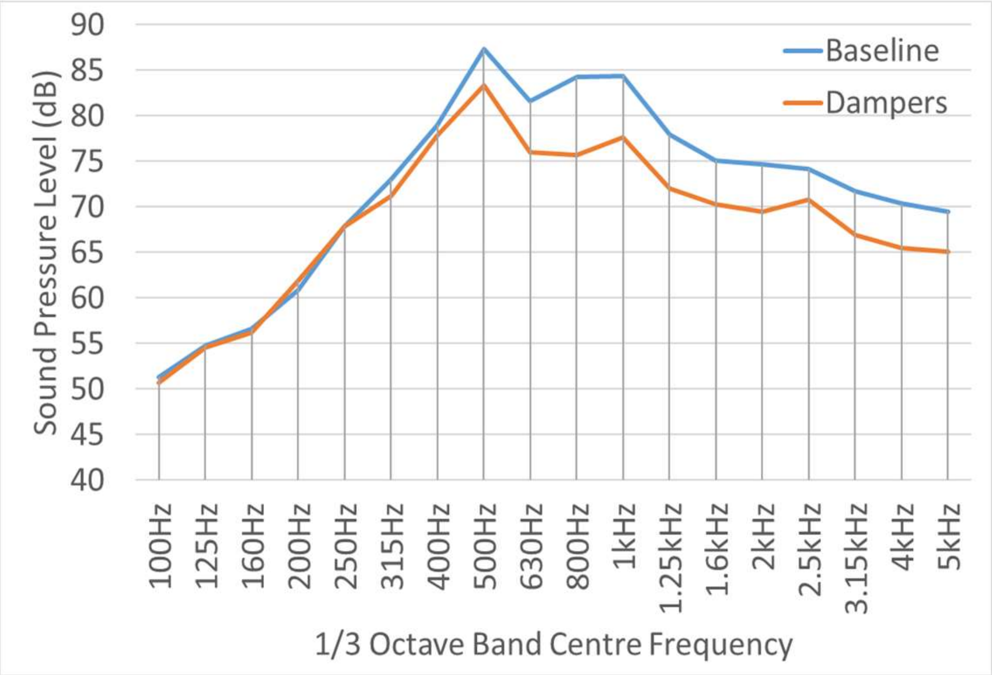
Vancouver damper spectral effect

Results shown for best scenario - Average 5 dBA benefit overall

- 4 dBA for MK1 train type
- 6 dBA for MK2 train type

Dampers effective above 500 Hz (most effective 800 Hz)

Benefit limited by corrugation at 500 Hz



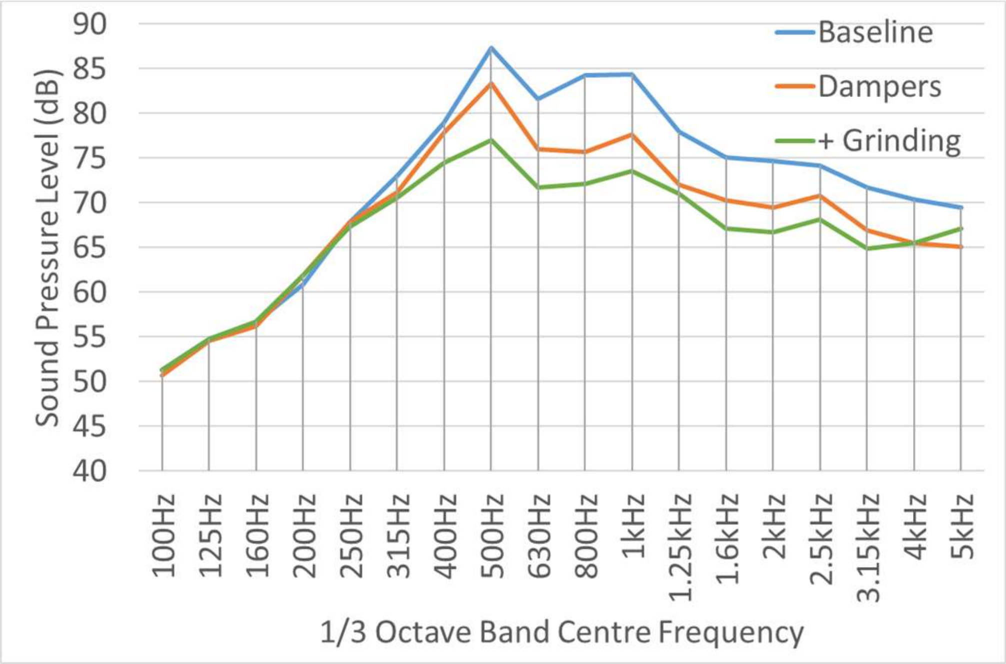
Vancouver – grinding + dampers

Bonus result – track ground soon after damper installation

Dampers + Grinding benefit

~10 dBA

Corrugation not completely removed



Measured Noise Effects - Ottawa

Scenario	Noise Reduction
Location at side of trench (measured immediately)	3 dB
Location at ground level (increased distance, measured immediately)	4.5 dB
Location on 9th floor balcony overlooking trench (increased distance, 2 month Covid delay to complete damped measurements)	4.5 dB +

Results complicated by 2 month Covid delay introducing temperature effects, possible roughness changes, variable speeds at site

Indications rail damper effect may be greater when measured at greater distances – more research needed

Summary

Rail dampers show 4-6 dBA noise reduction for Vancouver, Ottawa

Detail of results specific to system, configuration

Rail roughness / corrugation / noise frequency matters a lot

Vehicle type can influence damper effect

Physical trials very useful to confirm benefit of rail dampers for specific situation. Theoretical models are available but caution required applying these to slab tracks

Other comments

- Dampers designed for European ballasted / high speed / intercity lines may not be optimized for use on rail transit with slab track
- Still some unknowns particularly around theoretical modelling of damper benefit for slab tracks
- Consider all wheel/rail interface effects on noise – roughness / maintenance practices can influence rail damper benefit
- Future work – investigating if rail fastener type / baseplate design is a factor in rolling noise emissions

Acknowledgements

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