ACOUSTIC STUDIO

SAHAYA CONSULTING

RAIL TRANSIT SEMINAR

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August 26-28, 2025

WRI2025RT

SEATTLE, WA

WRI2025 30th ANNIVERSARY

Plasser American

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Noise outcomes from grinding and milling

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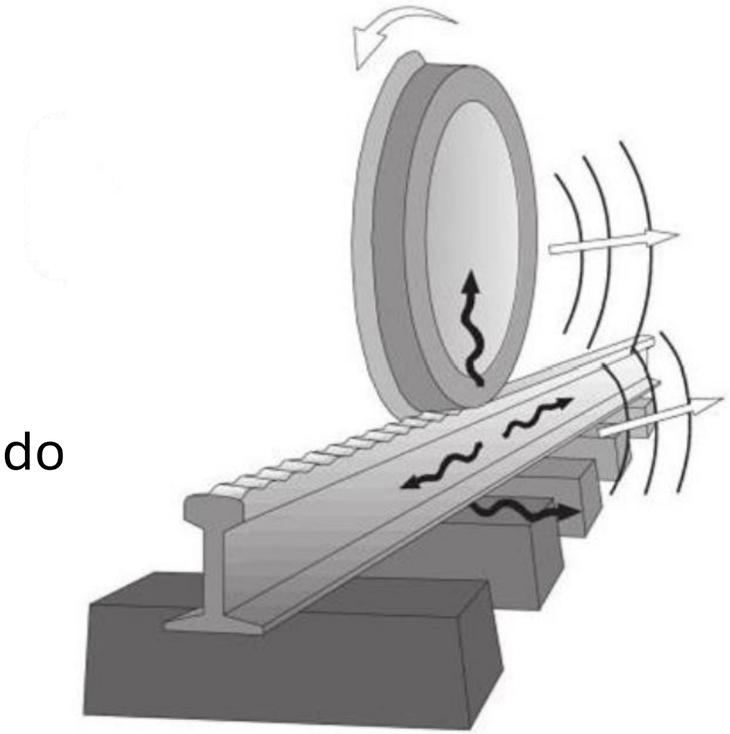
Overview

- Background
- Goals for “acoustic roughness”
- How acoustic roughness relates to noise
- Different rail maintenance methods and equipment
- What about the wheel – what does machining wheels do
- Acoustic rail roughness outcomes
    - Standard grinding
    - Acoustic grinding
    - Milling
    - Other new(ish) technologies
- Prediction method to determine noise benefit
- Noise outcomes

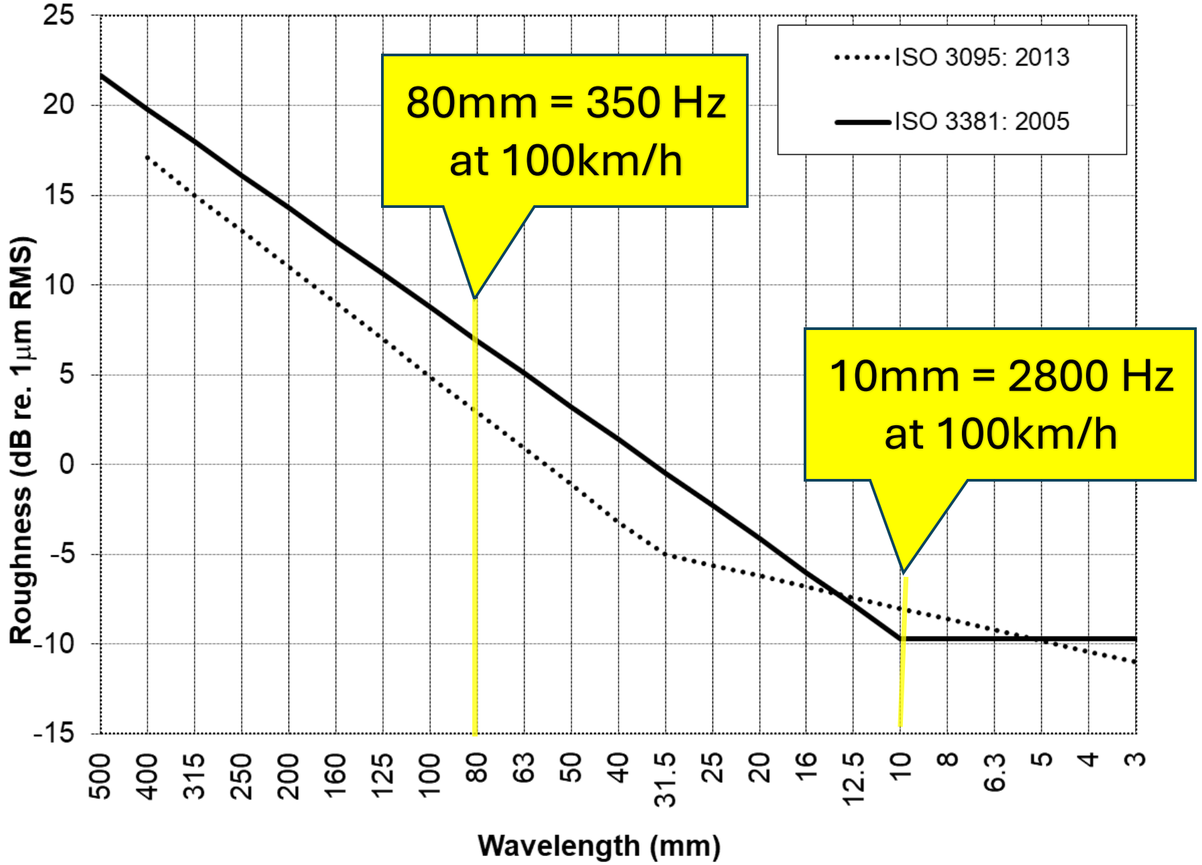


Background

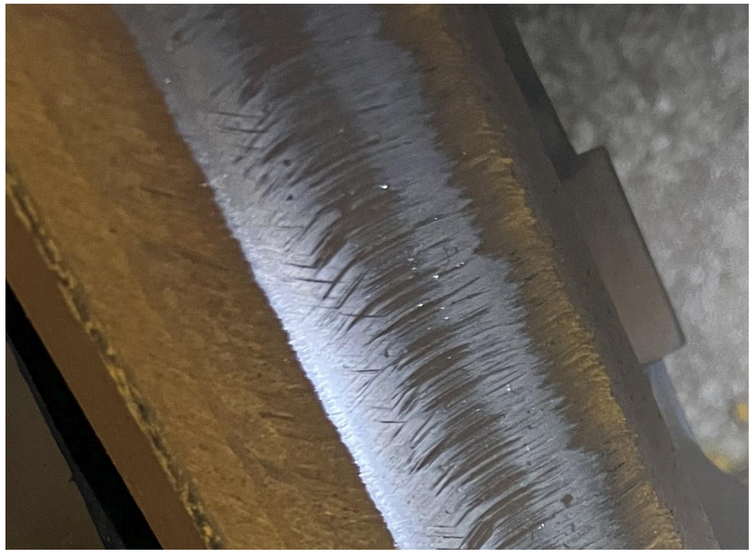
- Grinding is a necessary rail maintenance activity:
    - Remove mill scale
    - Install rail profile following construction
    - Restore profile following wear
    - Remove surface cracks / rolling contact fatigue
    - Regular preventative maintenance grinding
- Changing shape of rail – high metal removal 1mm +
- Preventative grinding ~ 0.2mm metal removal
- Acoustic grinding – surface polishing, minimal metal removal < 0.1mm, no change in rail shape

Acoustic Roughness References

- ISO standards
- Rail roughness is specified to define the track conditions for vehicle type testing
- Represents a very low level of rail roughness – track in very good acoustic condition
- Roughness wavelength and train speed combine to give noise frequency (pitch)
- For transit at 100km/h (60 mph) focus for noise is roughness wavelengths from 10-80mm

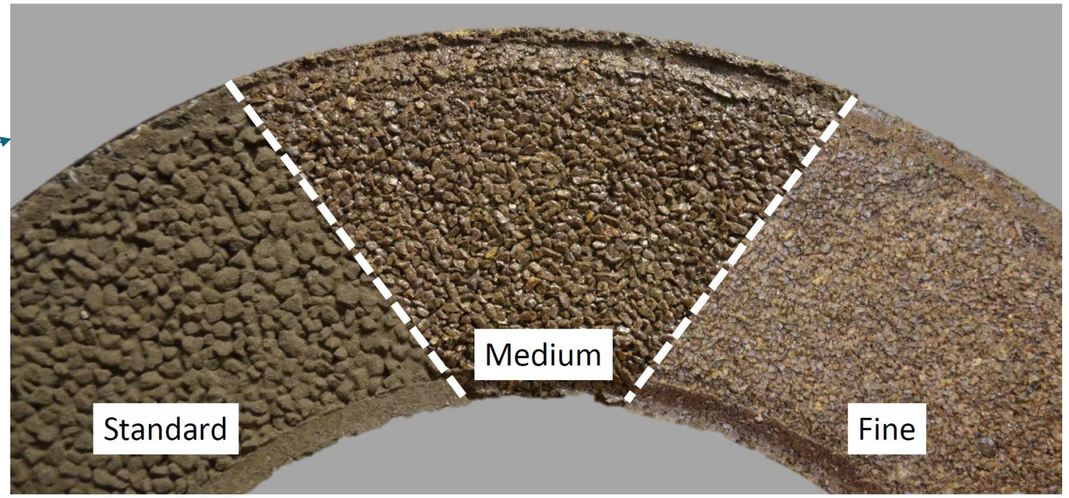


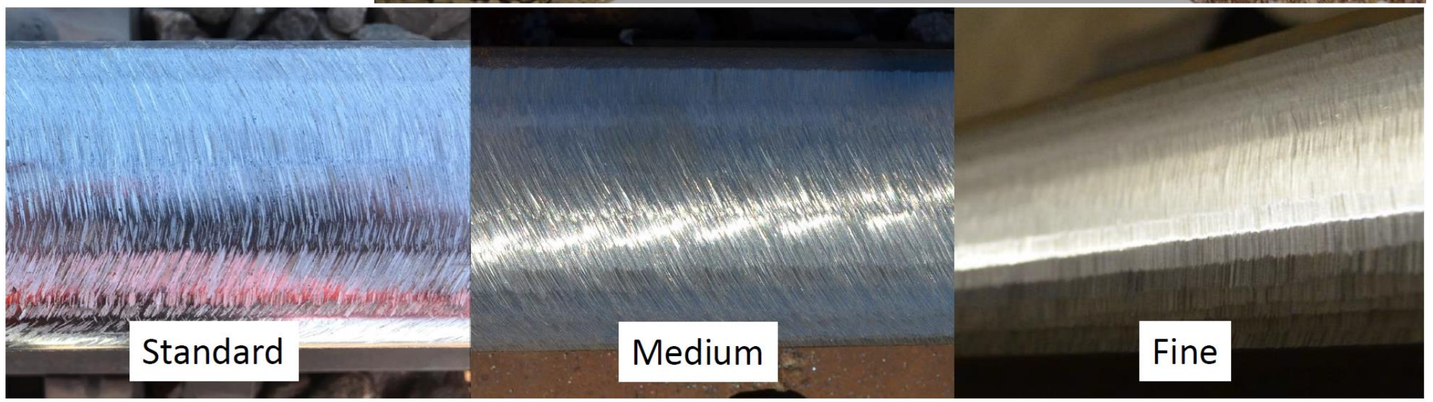
Grinding stones and surface roughness



Coarse / rough reprofile grind after three weeks of traffic

Images provided by LORAM





10-15 µm

5-10 µm

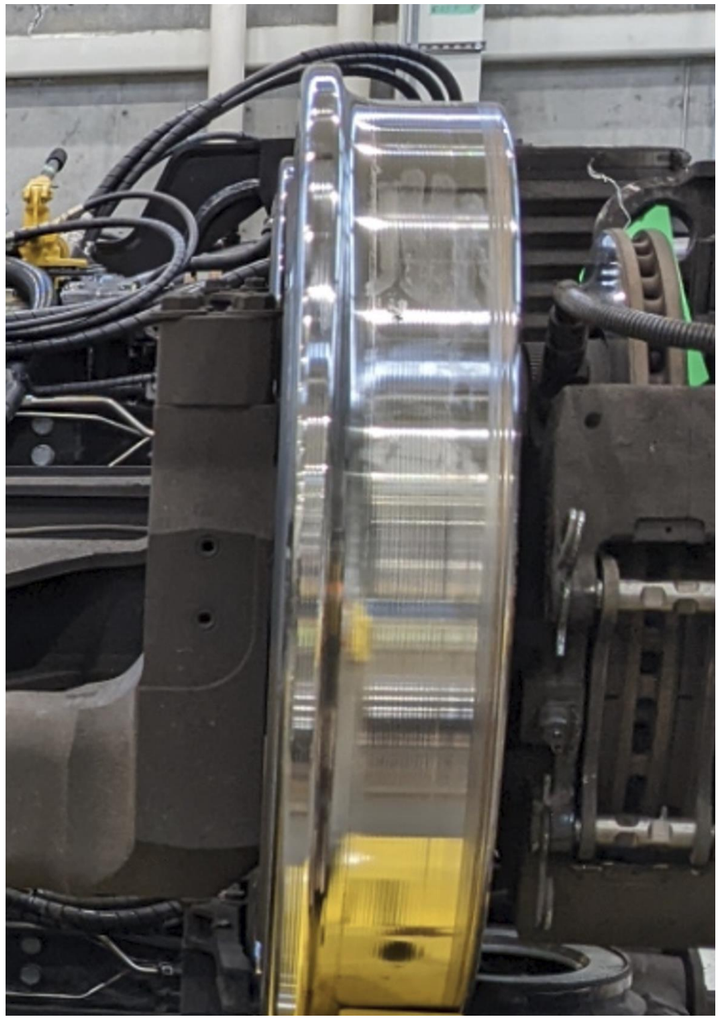
Under 6 µm

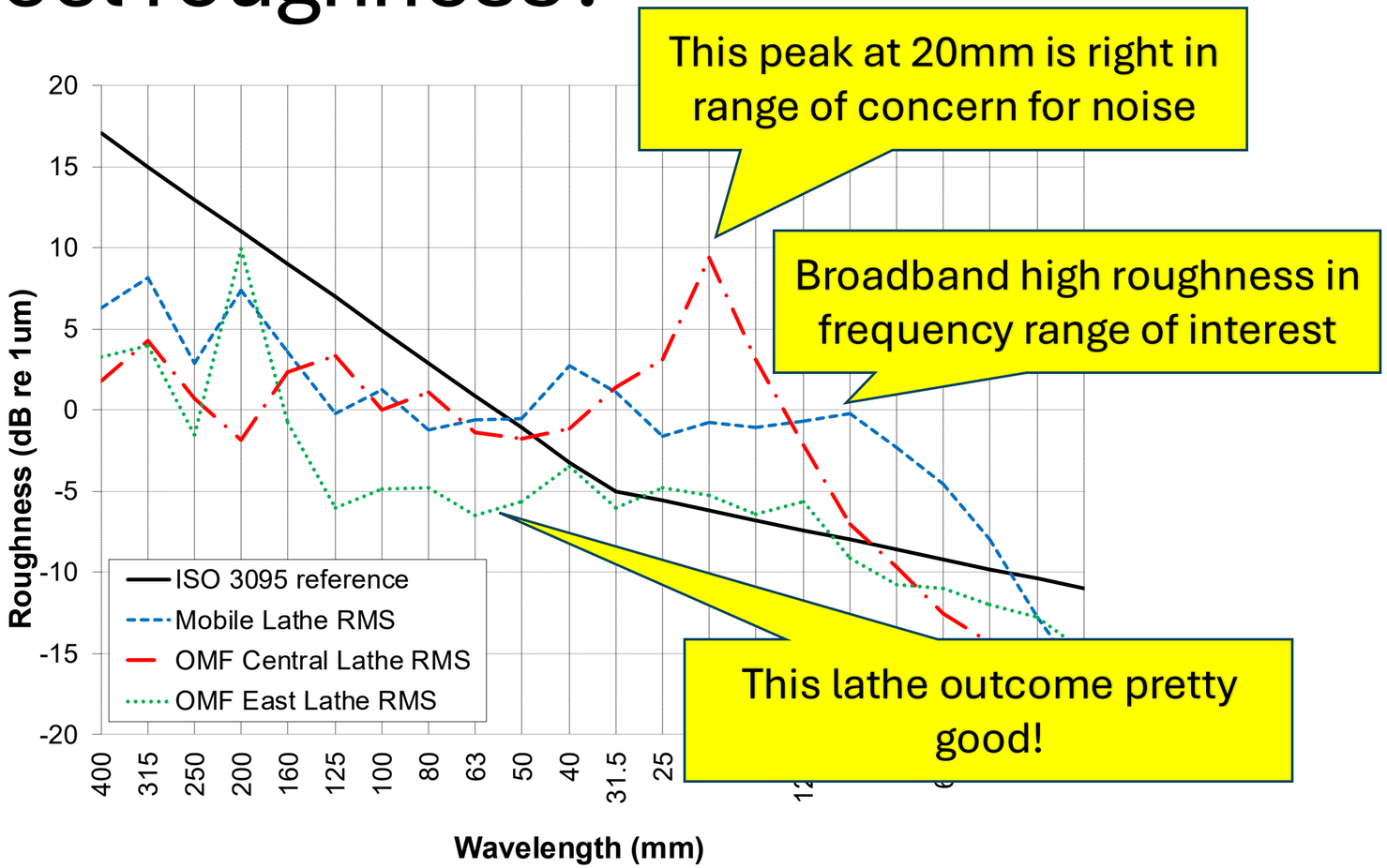
Rail Grinding – more surface finish examples

Left: wavy pattern attributed to a loose grinding stone.

Right: Sharp facets and periodic scratches visible immediately after grinding to install new rail profile.

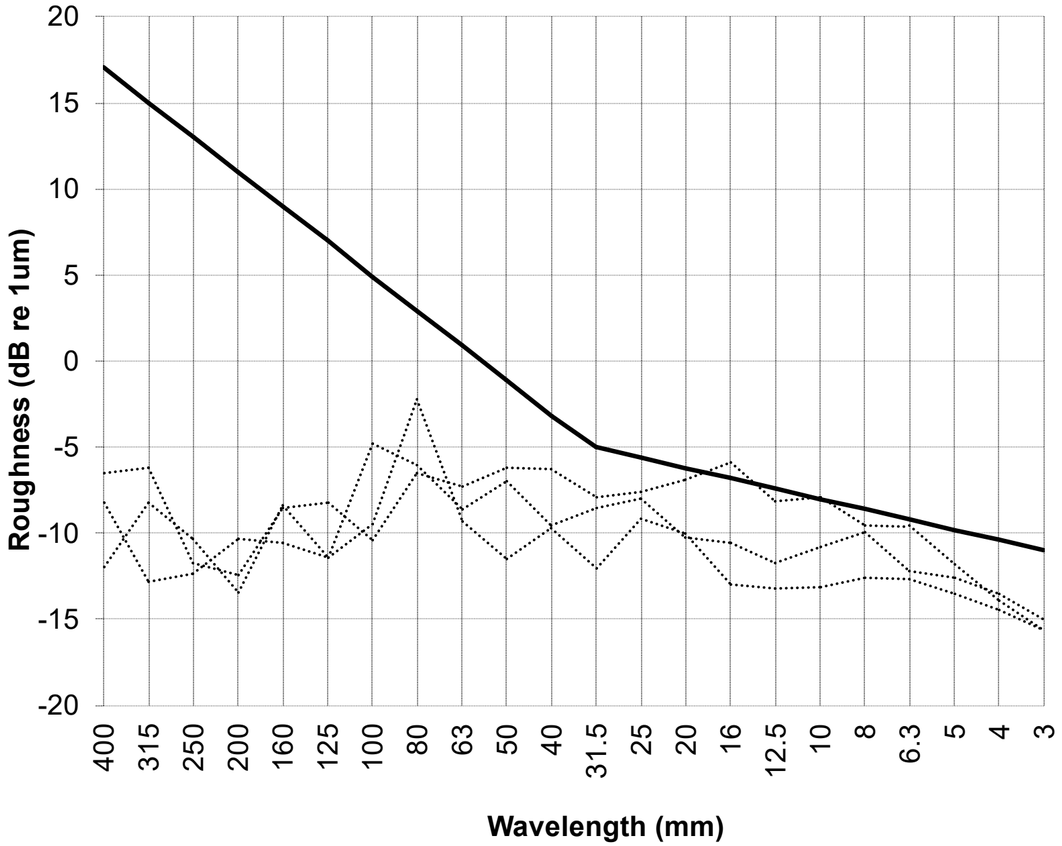
What about the wheel roughness?





Results immediately after wheel reprofiling
3 different lathes

But, wheel roughness wears in faster than rails



Variable outcomes straight off lathe but wear in very quickly in service

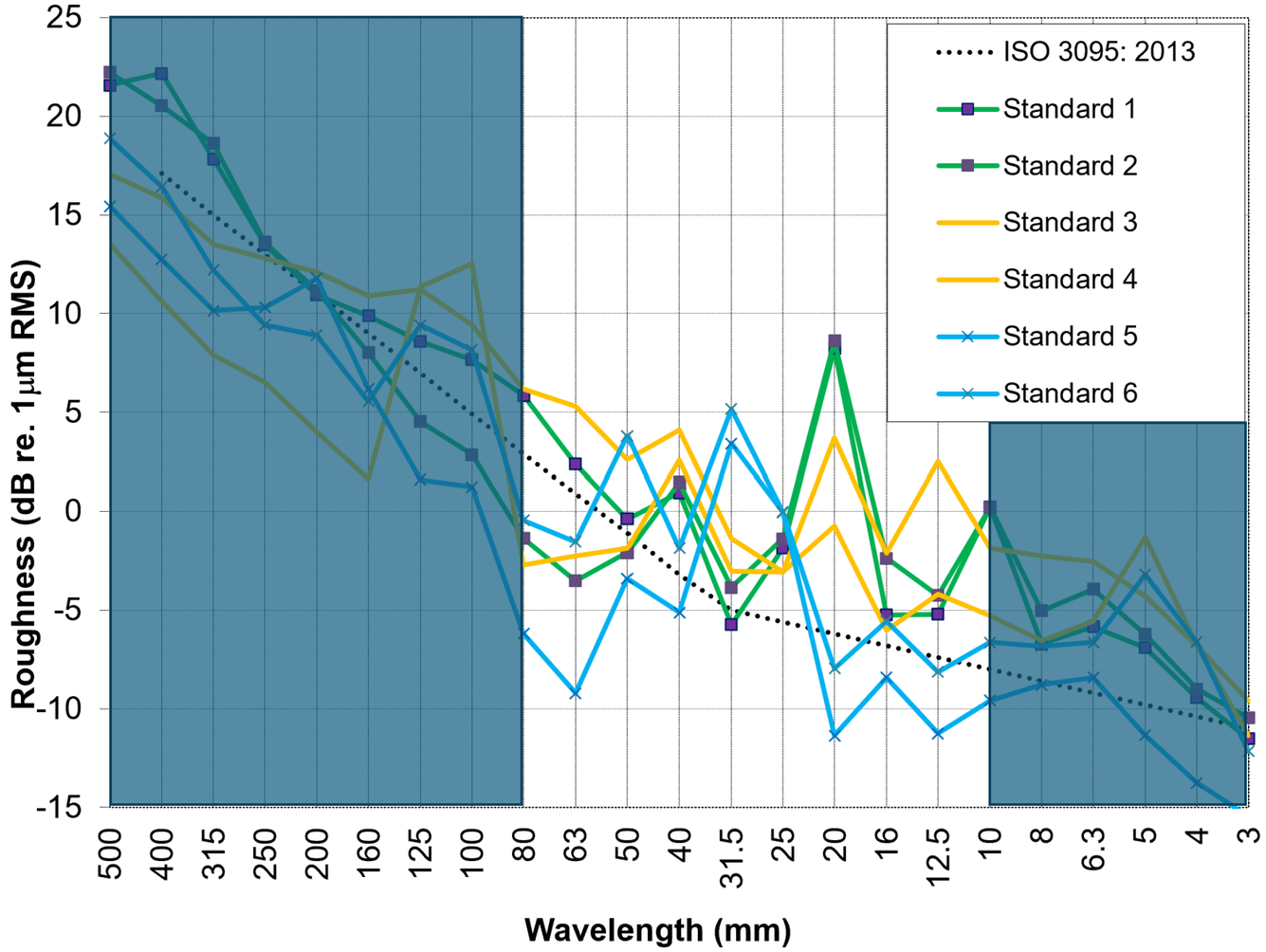
These results after 3300 miles

20mm peak in previous slide not evident in service

- For transit systems, rail roughness generally more important for noise than wheel roughness

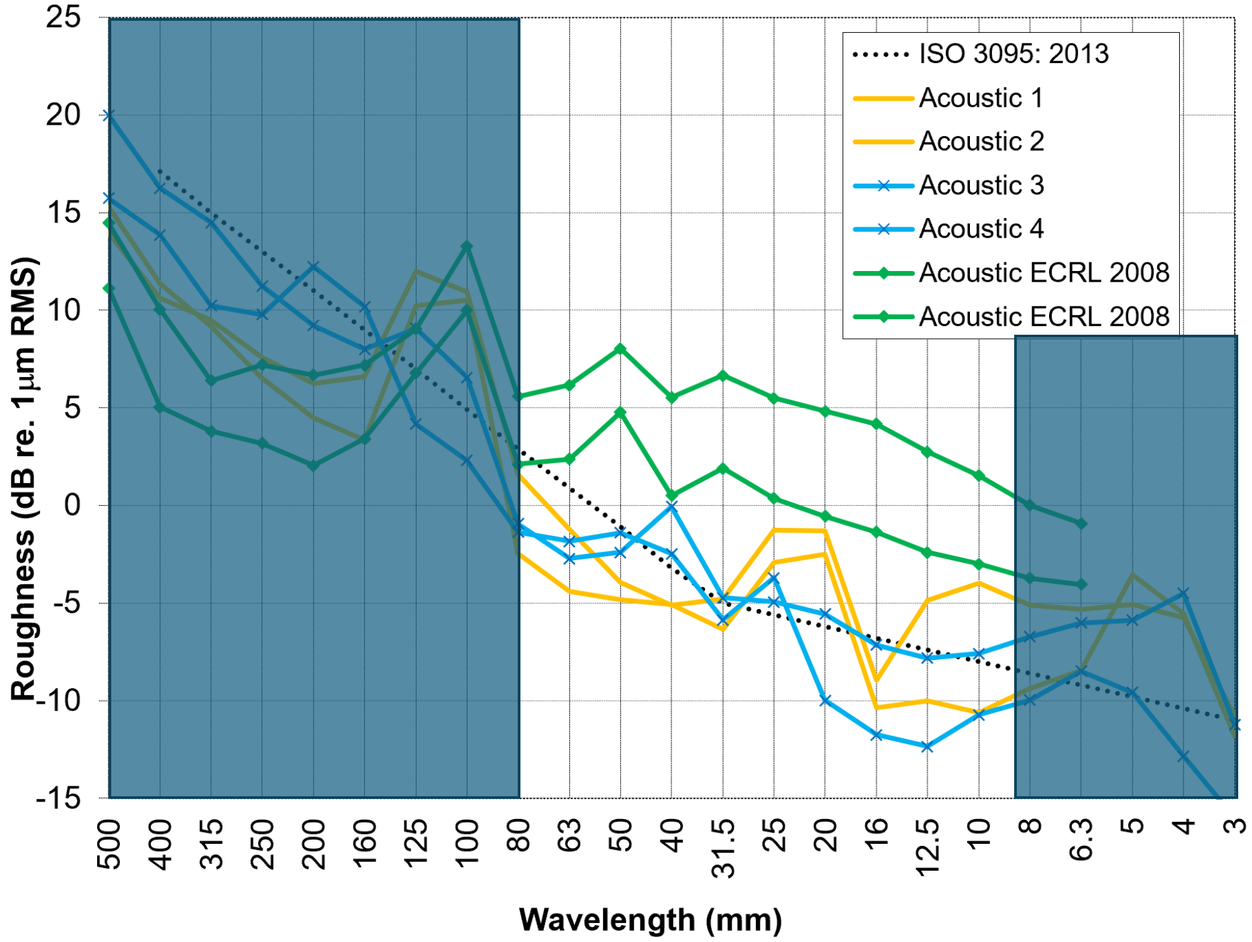
Standard grinding

- Examples from NA + Australian systems immediately or soon after grinding (days)
- Peaks from 20 mm to 50 mm are common, related to speed of machine and stone diameter, can be 15 dB above adjacent bands
- Higher speed grinding moves the main peak to longer wavelengths
- Medium grit stones
- Variable outcomes up to 15 dB above ISO 3095
- Note grinding to reprofile with coarse stones produces higher roughness



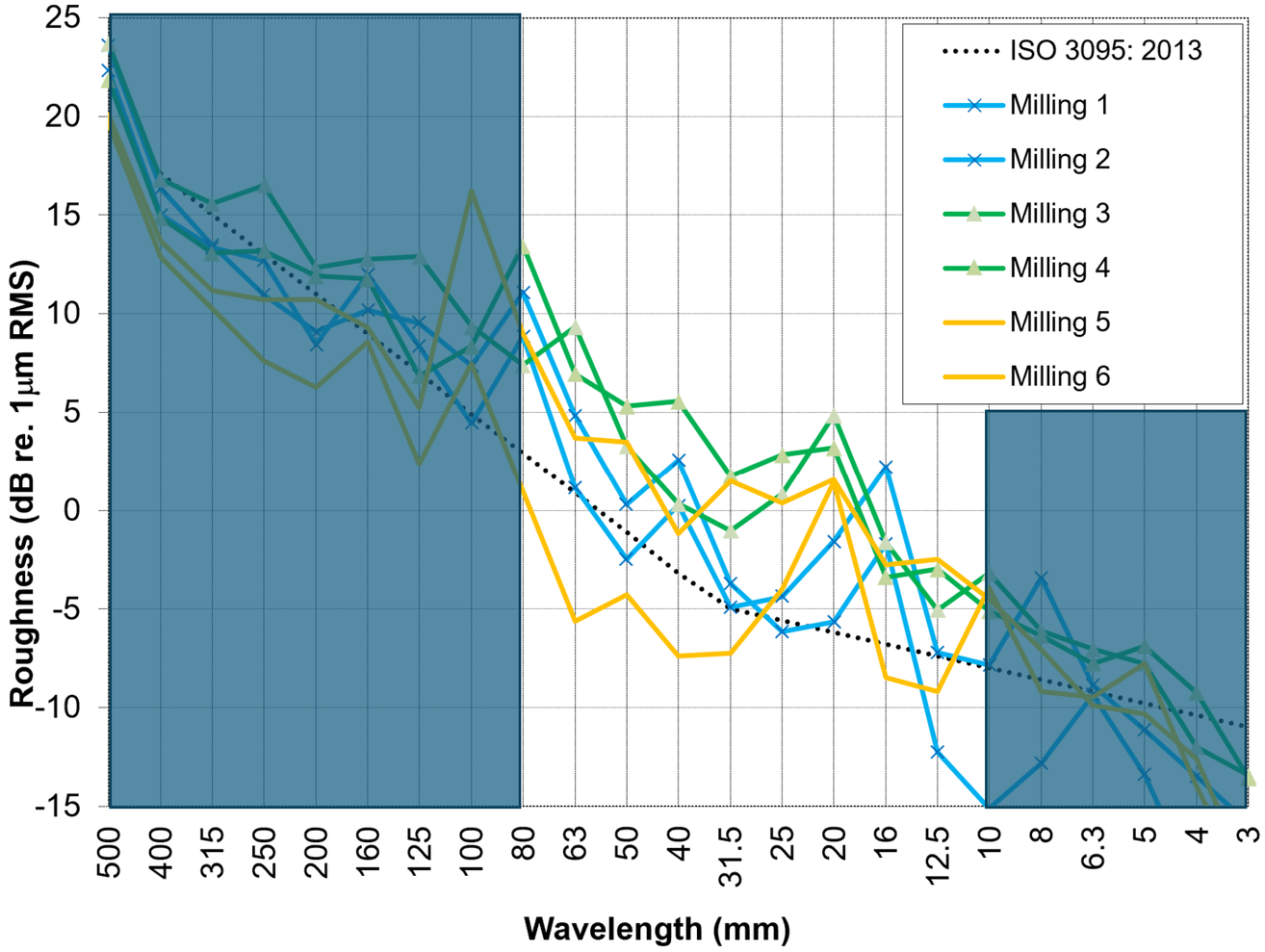
Acoustic grinding – standard grinding machines

- Examples from North American system (after a week) + ECRL (Sydney) 2008 (no traffic, freshly ground)
- Peaks less distinct
- Fine grit stones (NA)
- Higher speed finishing (ECRL)
- Outcomes variable but with finer stones can be within 5 dB of ISO 3095 reference in area of interest for noise
- ECRL benefit was shift in peak out to 100mm (outside range of concern for noise)



Milling

- Various Australian examples
- All without “polishing” included (some machines add a fine grinding stone following milling as a polishing step) – this gives better acoustic outcomes
- Outcomes from milling variable and up to 10 dB above ISO 3095 reference in area of interest for noise

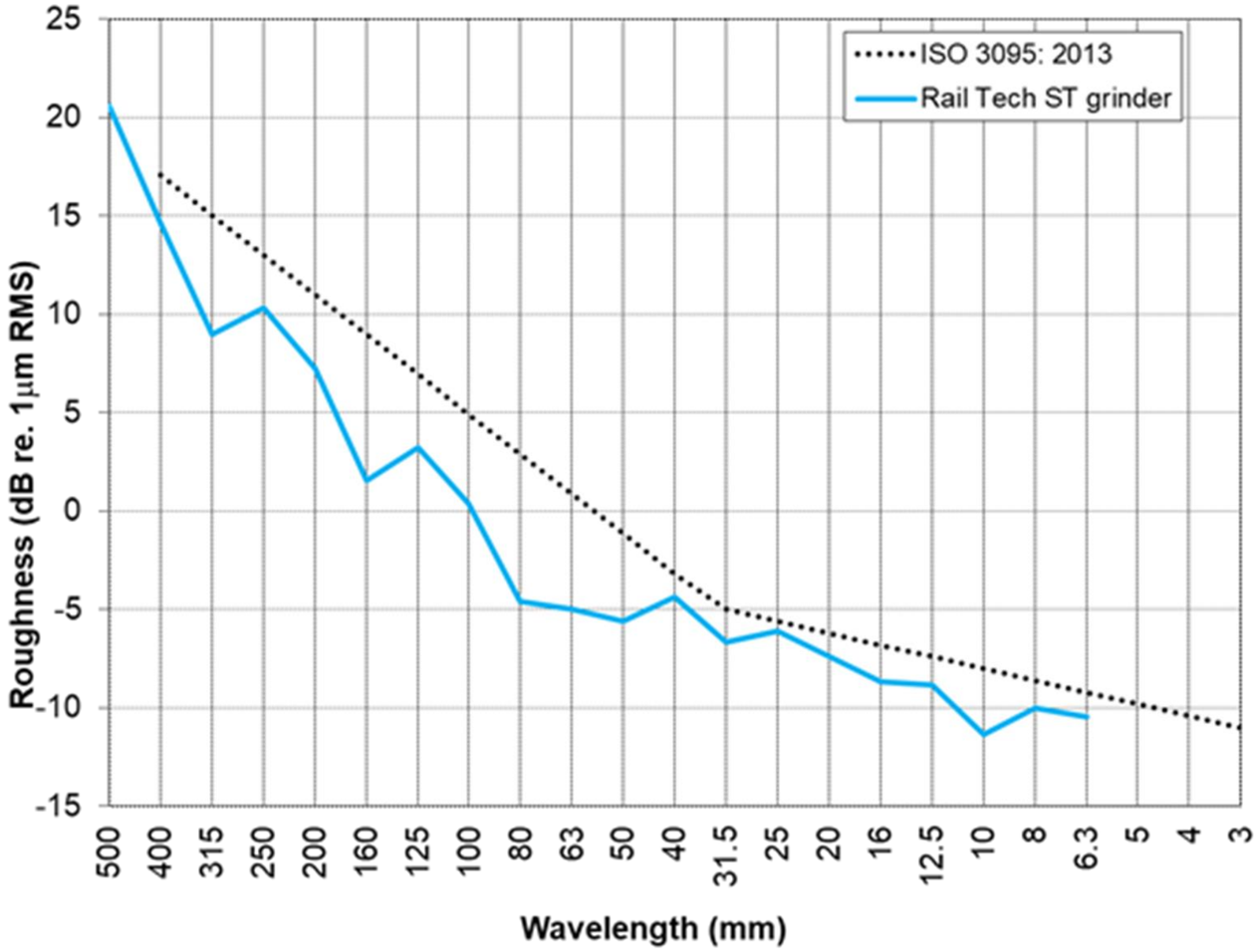


Acoustic Grinding – Rail Technology ST (Silent Track) grinder

https://www.railtechnology.com/rt-st-rail-grinding-technology/

ST Silent Track grinder

- Data provided by Rail Technology
- Measurements from yard trials
- No sharp peaks for tonal noise
- No traffic / no wearing in before measurement – short wavelengths unlikely to persist



Acoustic Grinding – Vossloh HSG-City

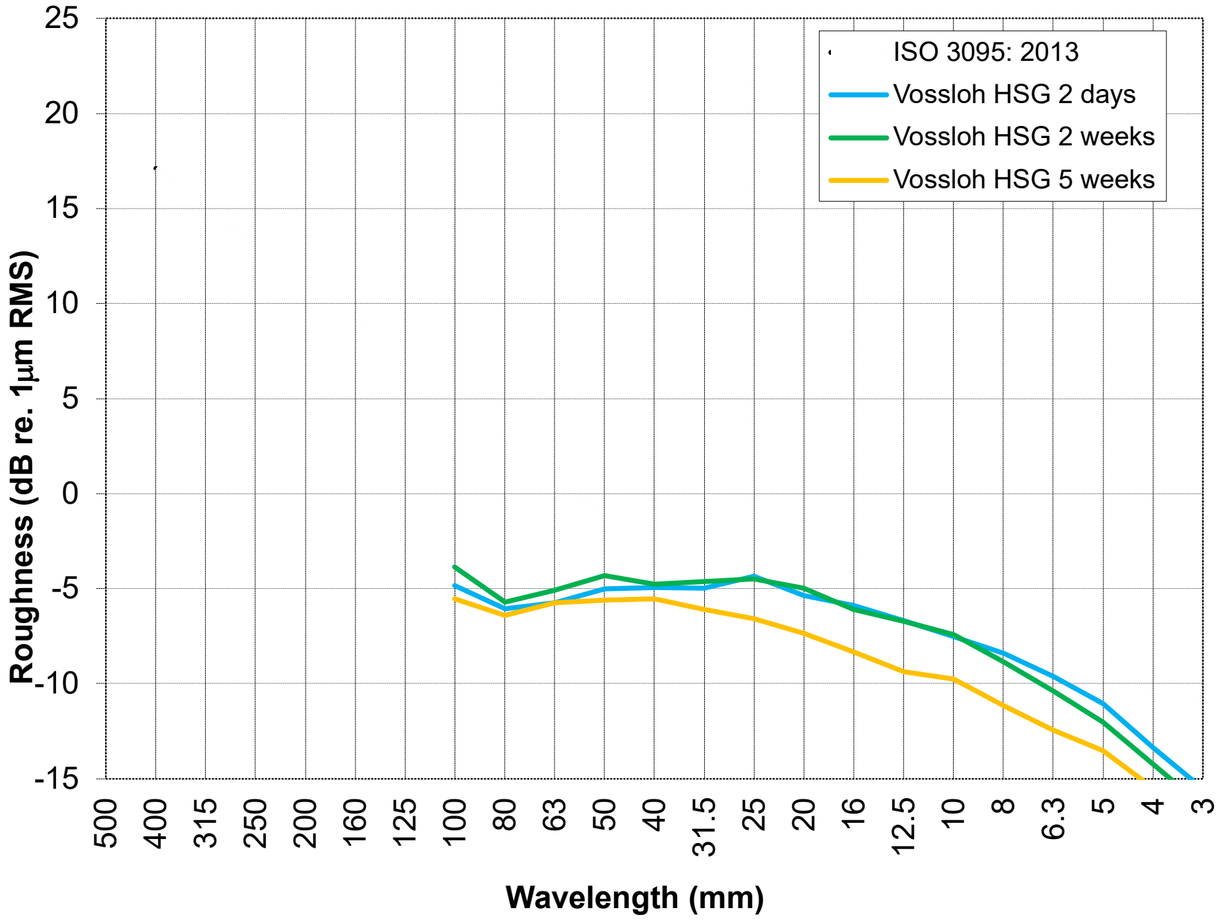
https://www.vossloh.com/en/products-and-solutions/product-finder/product_20928.php

HSG-City Grinder

- In use for 15+ years worldwide
- Relatively new in North America
- Up to 60 km/h grinding speed
- Multiple self driven stones
- Can use different stone types to get different metal removal rates and likely different roughness outcomes

HSG-City Grinder

- Data provided by Vossloh – measured by Müller BBM (mixed traffic line, Germany)
- 6 sites monitored over several weeks following each of three grinding campaigns
- Example is average from two sites, 2 days after grinding, then at 2 weeks, then 5 weeks
- Rail hardness unknown, likely 260 HB (standard rather than premium)
- No sharp peaks for tonal noise



Acoustic Grinding – Plasser Atmo block grinder

Still looking for measured roughness data for this one

https://www.plassertheurer.com/en/machine/mobile-rail-rectification/rail-grinding-machines/plasser-atmo

Worn in roughness – softer / standard rails

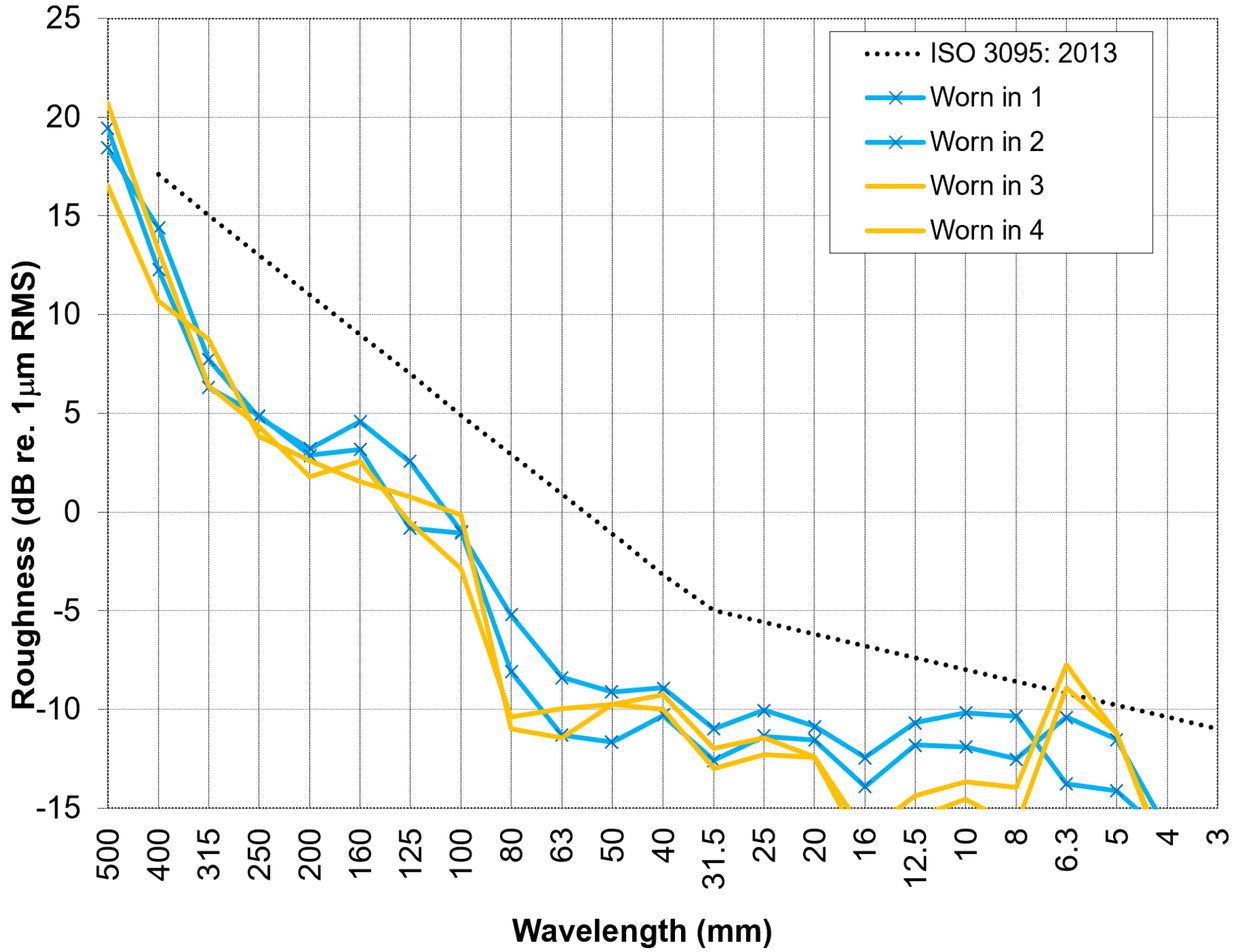
Grinding induced peaks can remain in rail for months (years?)

But if a good finish is achieved rails can wear even smoother in weeks

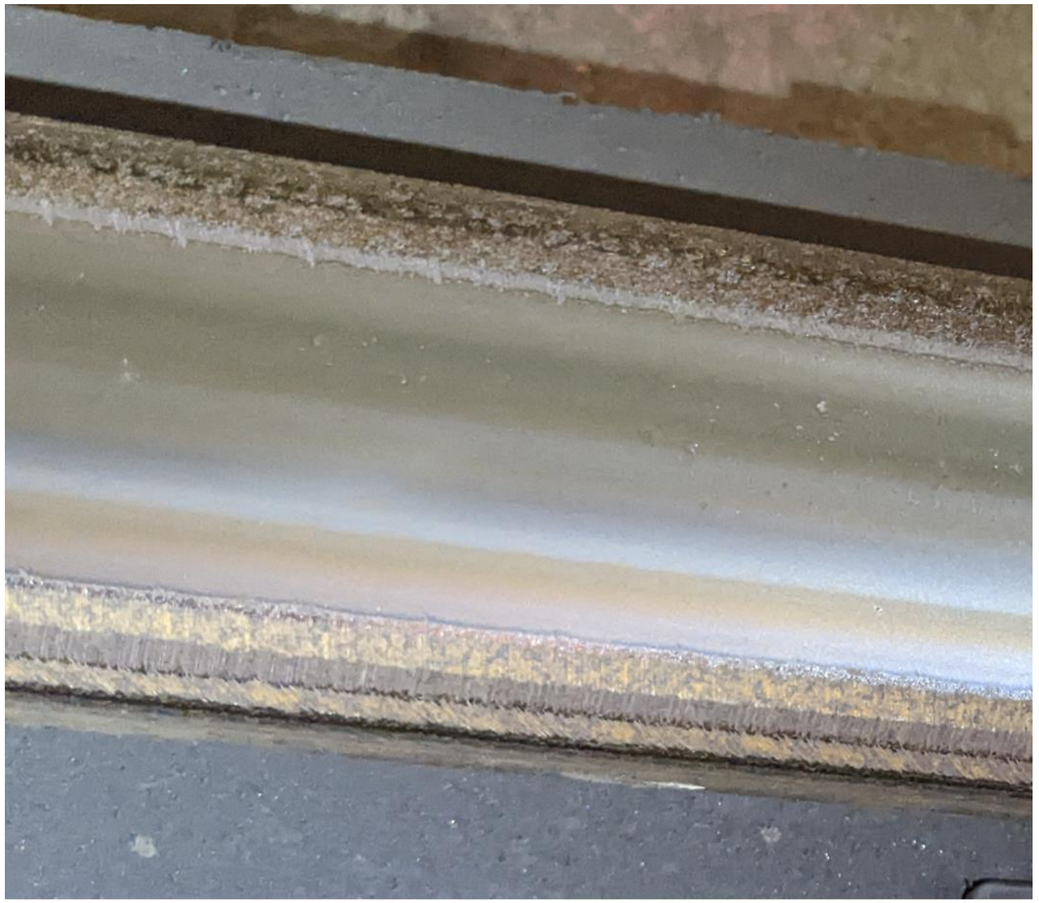
Two examples each with two rails measured from metro system with no recent grinding

Note that rails don't always wear smooth – complex topic:

- Rail hardness is a factor
- Traffic and axle load is a factor
- Some systems get smoother over time, others roughness increases over time



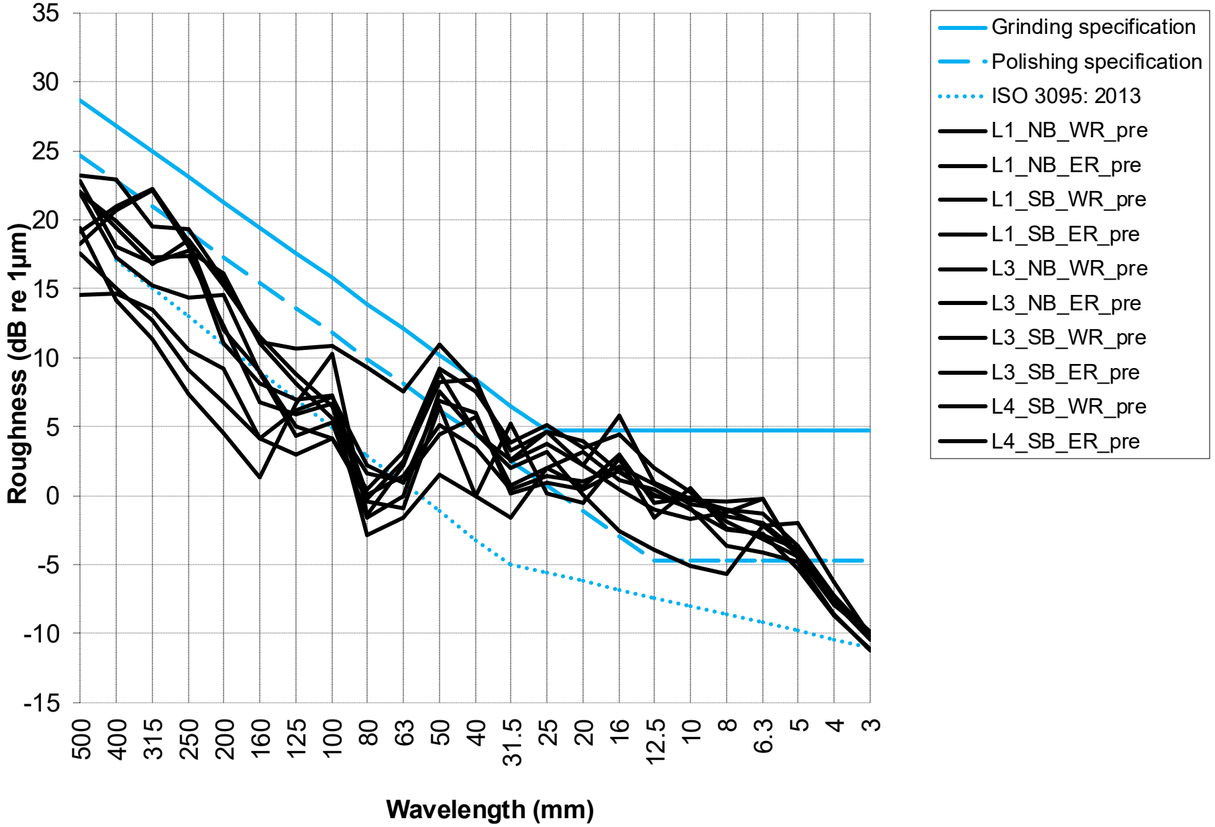
Worn-in roughness – softer rails



- No residual grinding marks visible in running band
- Some marks outside running band
- Small pits not relevant to noise – contact patch is larger than these and the roughness processing removes small pits and spikes
- No obvious periodic patterns

Worn in roughness – harder / high strength rails

- Worn in roughness - Seattle
- Rail roughness before grinding, multiple tracks and rails across 3 locations
- Seattle grinding and polishing specs shown along with ISO 3095
- Grinding and polishing to Seattle specification tends to reduce roughness and noise.
- Elsewhere (eg Sydney) grinding increases roughness and noise relative to worn in roughness.



Worn-in roughness – harder rails

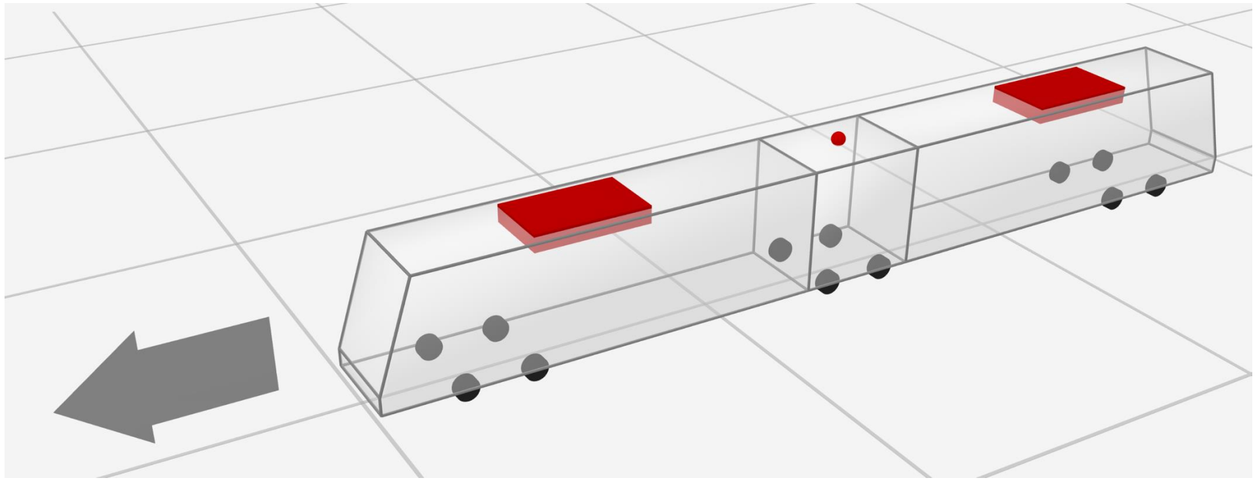
- Residual grinding marks in running band
- Usually a dominant signature in the 20-50mm wavelength range
- Photos don’t tell whole story – micron roughness needs measurement to quantify

Influence on noise

- Train Noise Expert (TNE) – rolling noise modelling
- Calculate noise effect of different roughness scenarios:
    - Worn in
    - Rough reprofile grind
    - Acoustic grind using standard equipment (best possible outcome, requires fine stones, expensive and extremely difficult to achieve)
    - “New tech” acoustic grind (can be reliably achieved by specialist equipment)

TNE modelling

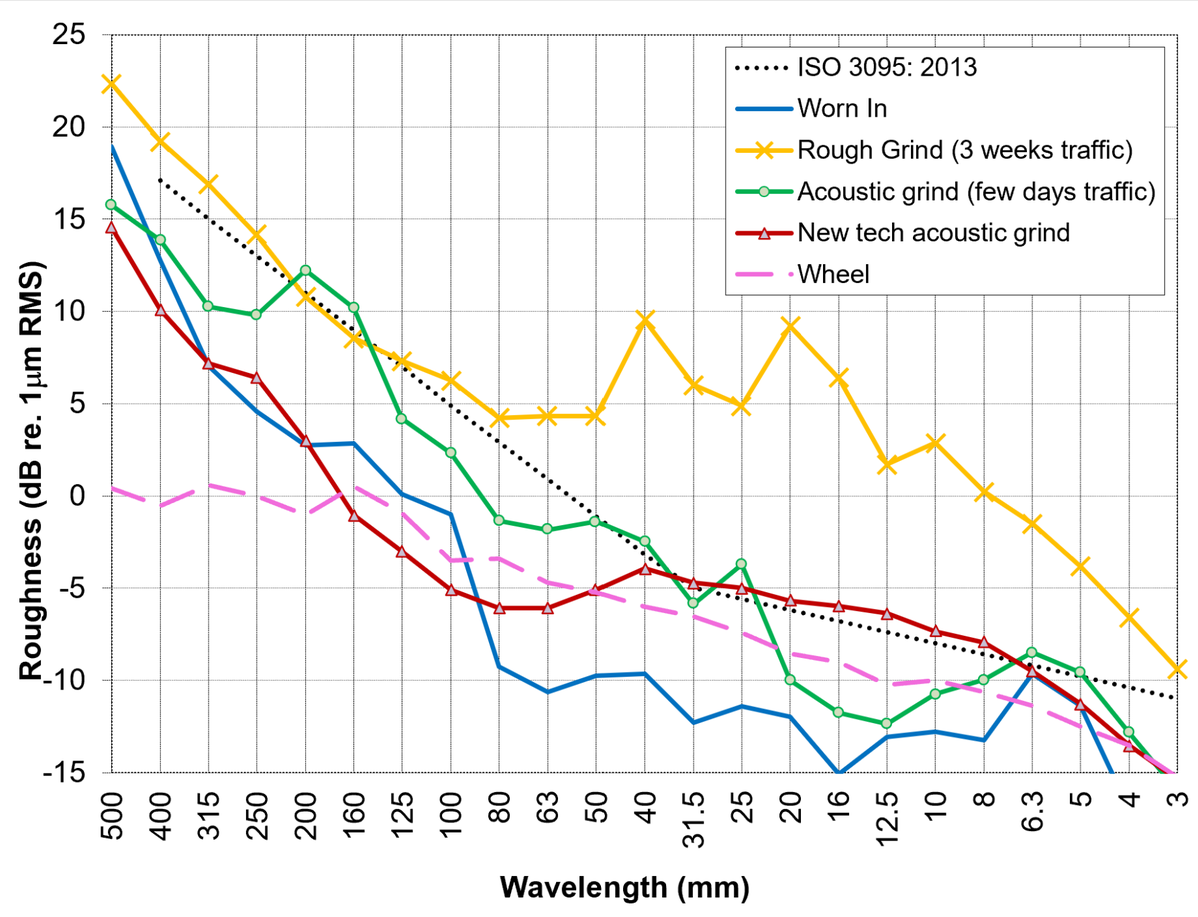
- Metro train on resilient direct fix slab track at 100 km/h with wheels in good condition
- This type of model can be used to test effect of changes to track components, wheel design, or system roughness
- Also to predict effect of rail dampers on a particular system



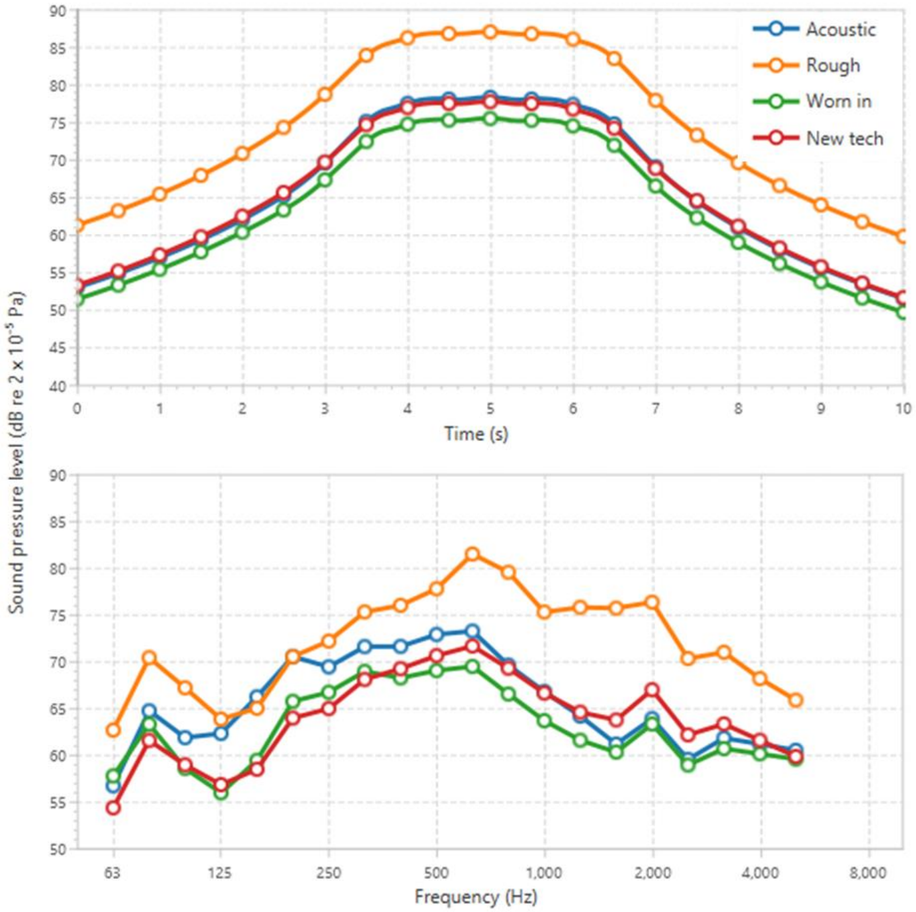
Equipment noise (HVAC and Pantograph) can be modelled, not relevant for this study as not a a significant contributor to overall passby noise at speed

Roughness inputs to TNE

- Worn in – as measured on a metro system
- Rough grind – as measured 3 weeks after reprofile grinding on same metro system
- Acoustic grind – a few days after careful acoustic grinding with fine stones
- New tech – composite of ST and HSG assuming some traffic
- Wheel – median of 50 measurements of wheels with 1000-40000 miles after machining



Noise effect of grinding outcome



Scenario	LAeq(passby) at 15m (dBA)	Change from worn in (dBA)
Worn in	74.9	-
New tech	77.2	2.3
Acoustic grind	77.7	2.8
Rough reprofile grind	86.4	11.5

Intermediate outcomes also possible
Milling (not modelled) would be an intermediate outcome (depending on if polishing stones are part of the process)

Research questions

- HSG-City performance with various different stones, rail hardness, operational speeds
- Plasser Atmo block grinder outcomes
- Rail Technology ST grinder outcomes on working networks

- Effect of pre-grind condition on outcomes?

- How best to use these specialist machines as a complementary option in the rail maintenance toolbox

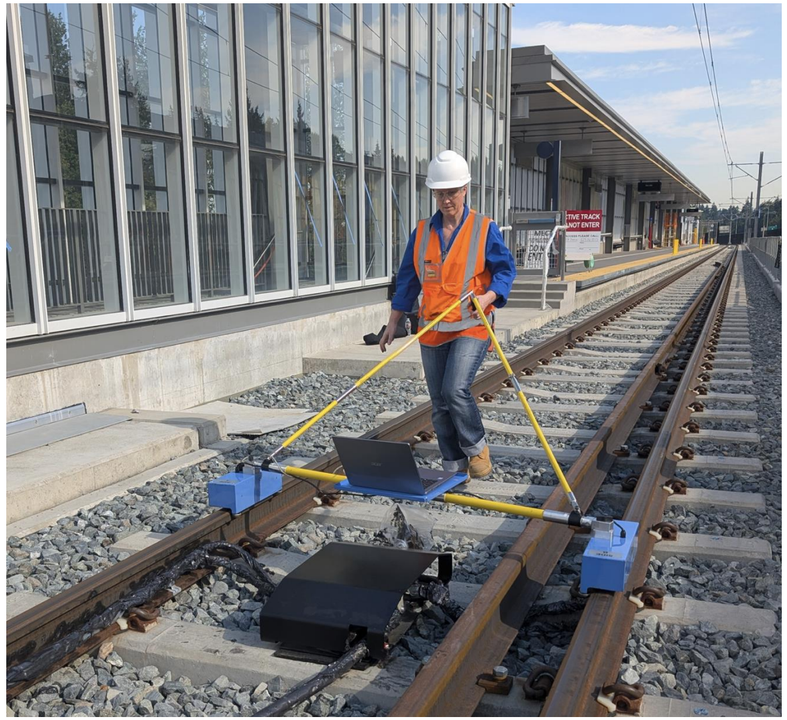
Summary

- Wide range of roughness and hence noise outcomes
    - Equipment available
    - Settings, stones and operator experience
- Grinding specifications for regular maintenance (reprofiling) often do not address noise outcomes – can increase noise by more than 10 dBA
- Technology is coming available to reliably improve roughness and noise outcomes
- Recommend separation of maintenance re-profiling from acoustic roughness treatment
- Consider specific situation and time to wear in – acoustic finish after grinding less critical with softer rails than harder rails

Acknowledgements

With thanks to all those who provided roughness measurement data, information and pictures

Questions + discussion



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