Rail Corrugation

Pervasive, Persistent, Preventable?

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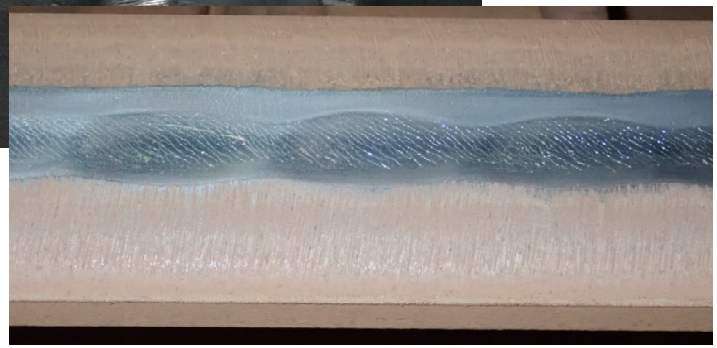
PERVASIVE

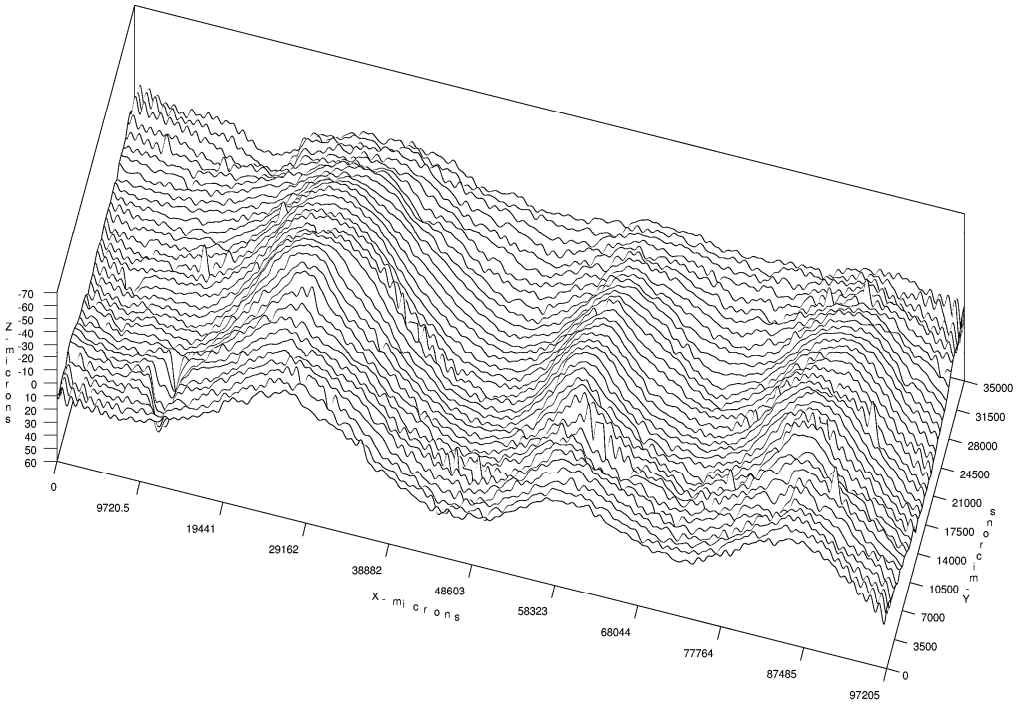
(especially of an unwelcome influence or physical effect) spreading widely throughout an area or a group of people

BART



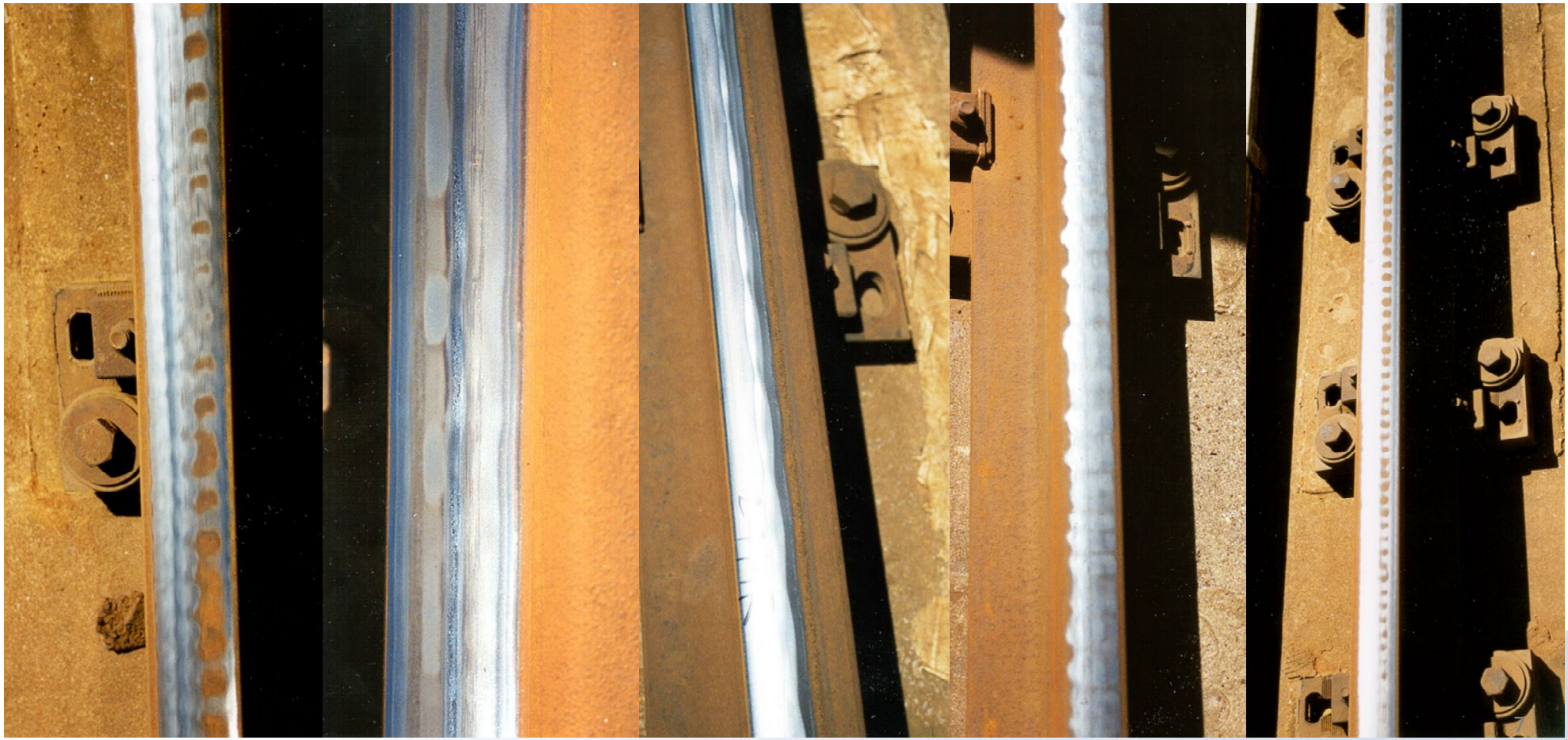
Canadian Transit

Cleveland (2003)



Medellin, Colombia (1998)

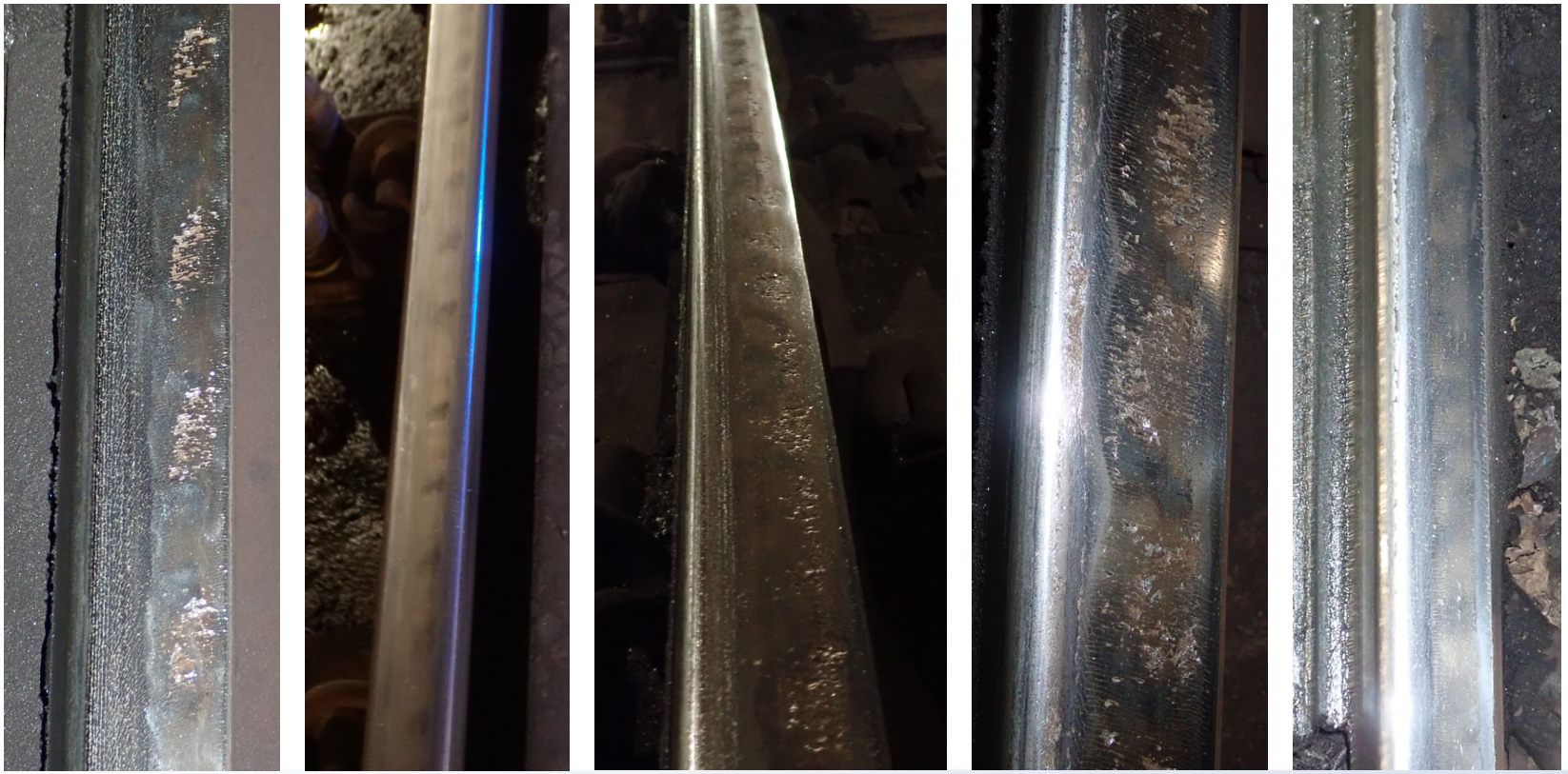
Detroit people mover (1999)



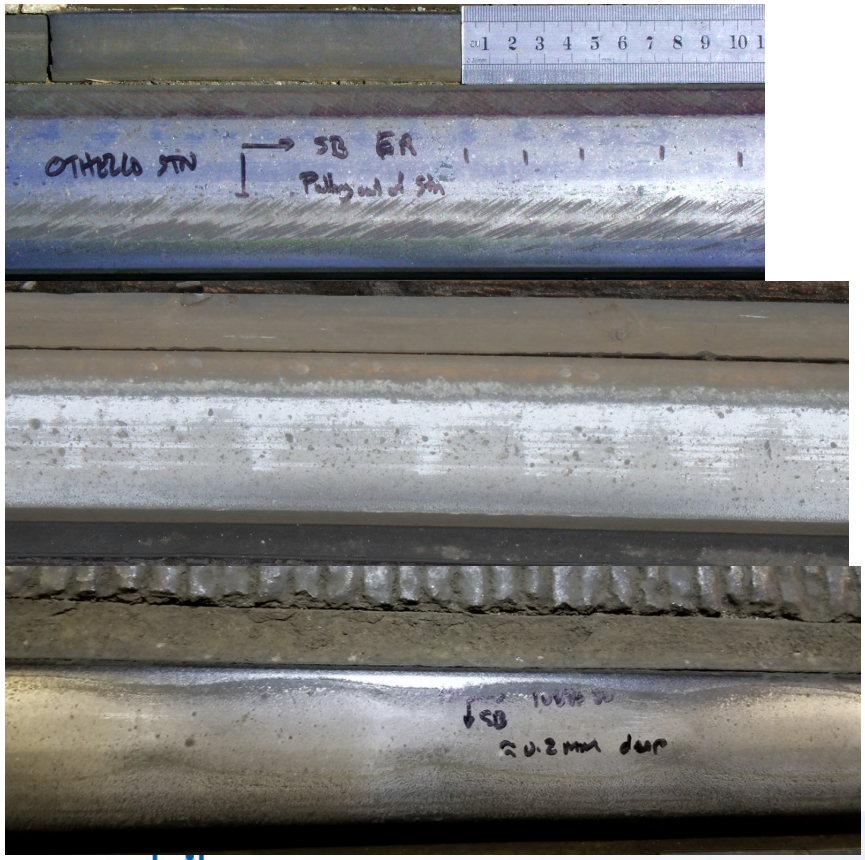
London Underground

Photos – courtesy of Andy Vickerstaff (TFL, 24MAR22)

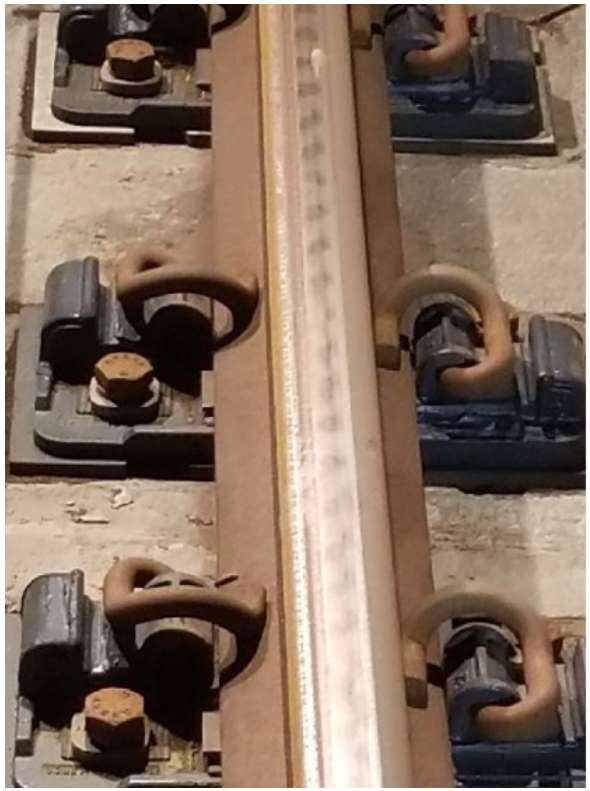
New York City (2019)



Seattle (Sound Transit)



Vancouver Skytrain



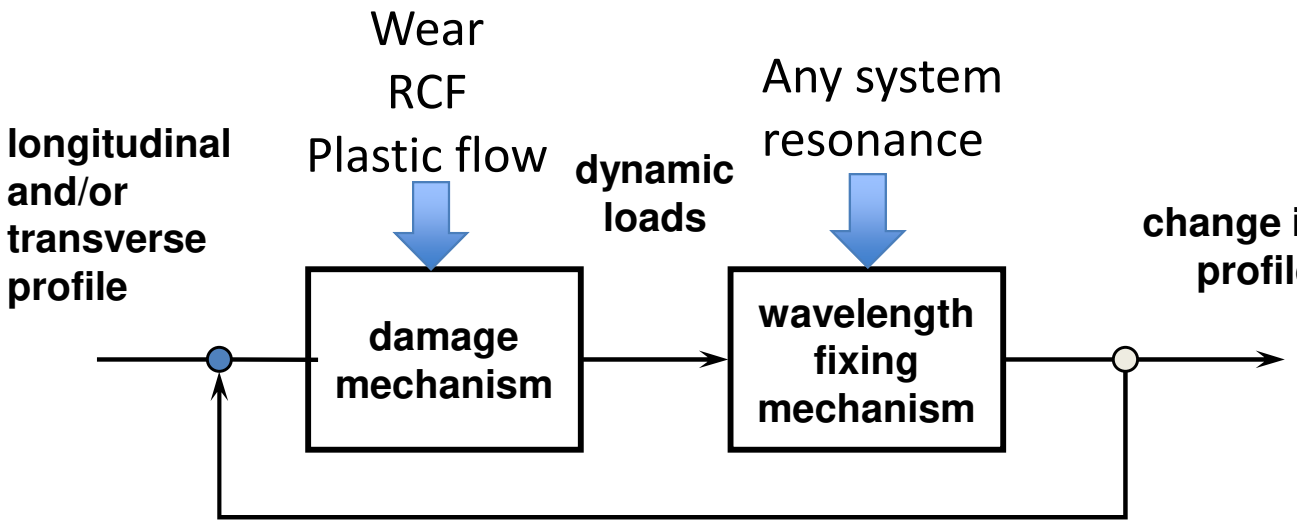
From: Vesik, Croft, Reimer and Eadie
Quantifying Friction Modifier Effects on Rolling Noise, Roughness and Corrugation Growth
ICRI presentation December 2021

West Coast US Transit

PERSISTENT?

continuing to exist or endure over a prolonged period

Components of a General Corrugation Mechanism



From Grassie and Kalousek, 1993

System Resonances

Vehicle

- Wheelsets:
  - Unsprung mass
  - Radial, lateral resonances
- Axle
  - Bending, torsion
- Motor-wheelset linkages

Track

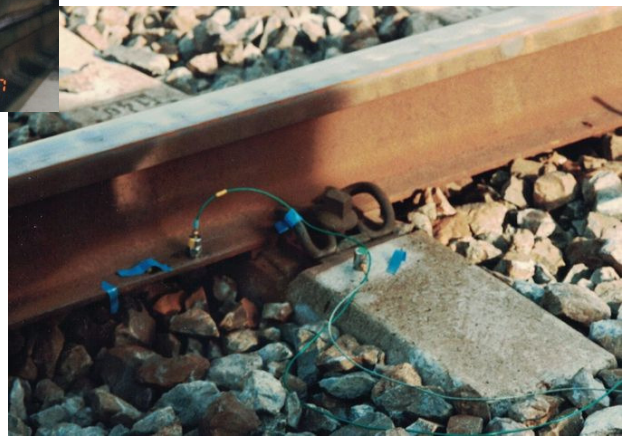
- Rail
  - Pinned-pinned
  - Lateral, torsional
- Rail ties/fastener
- Booted sleeper
- Embedded
- Negative friction

PREVENTABLE?

able to be prevented or avoided

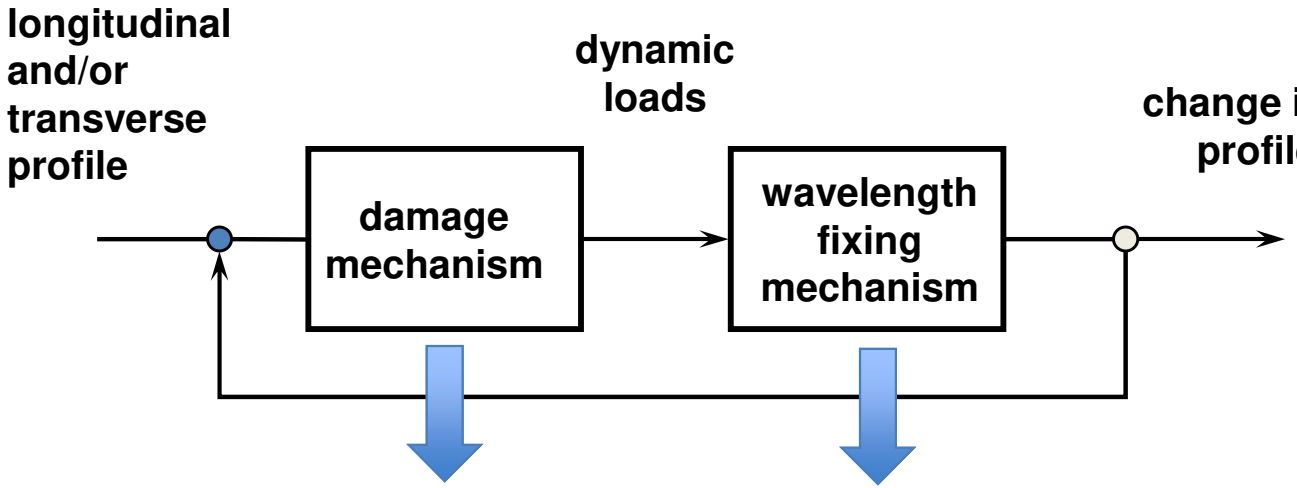
Example – South America

Field work



Rail grinding practices

Components of a General Corrugation Mechanism



Summary

- Pervasive: every railway, of all shapes and sizes
- Persistent: It is a natural phenomenon, unavoidable, will return, must be treated
- Preventable? Not completely, but can dramatically minimize and treat practically

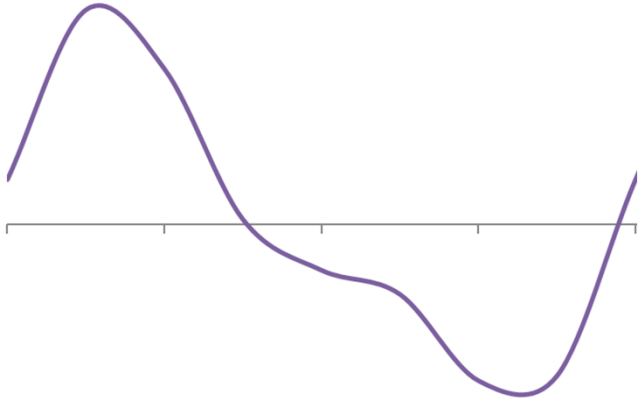
Prevention begins with data

Key corrugation data collection questions:

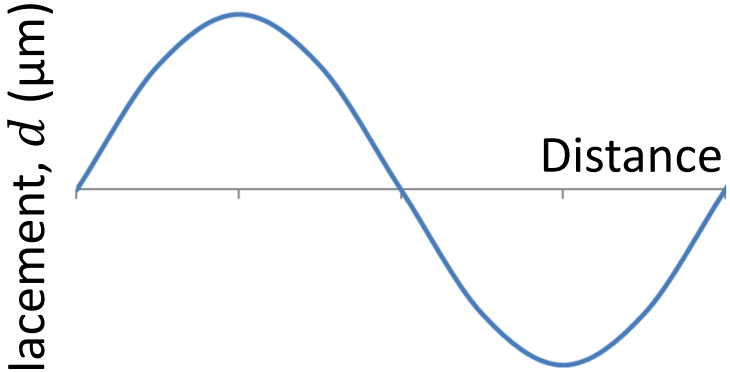
- **How do we summarize corrugation data spatially?**
- **Do track-related characteristics matter?**
- **How often and when should we measure?**
- **Can we integrate corrugation data with other data streams?**

Spatial summarization

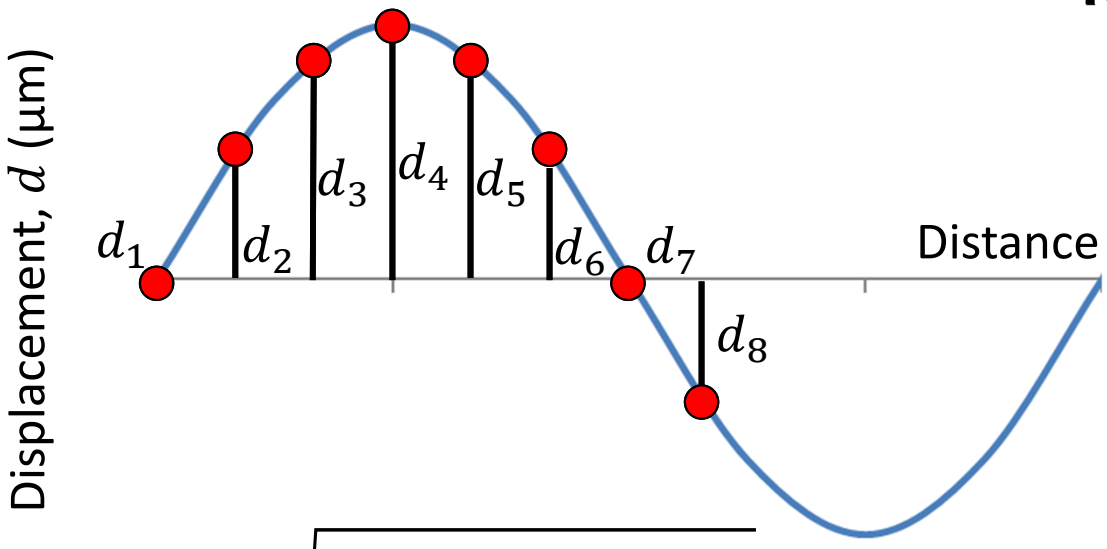
CAT outputs a vertical displacement signal for each rail



CAT software applies filters to focus on corrugation “bands” of interest (typically 30 to 100-mm wavelengths)



Spatial summarization

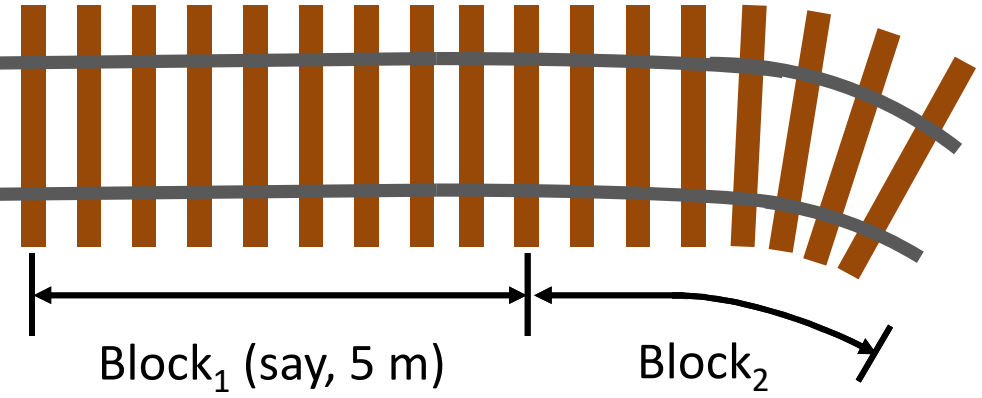


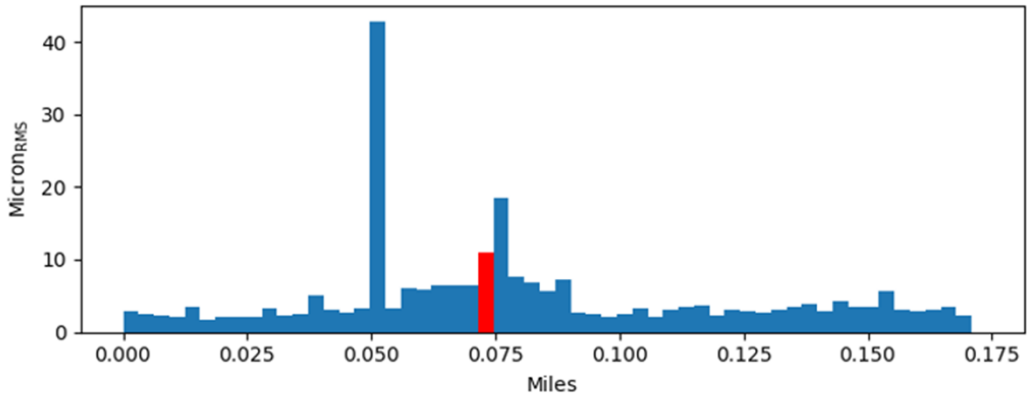
$$RMS = \sqrt{\frac{1}{n}(d_1^2 + d_2^2 + \cdots d_n^2)}$$

RMS, discrete case ($n = 8$)

- **Square each displacement (takes care of negative values)**
- **Take mean of squares**
- **Take square root**
- **A measure of the roughness of an oscillating signal**

Spatial summarization

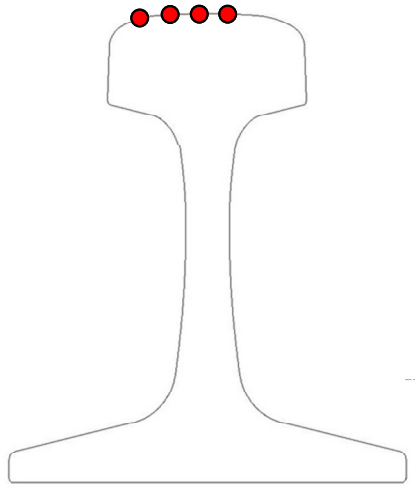




- **Consider a 0.2-mile track segment**
  - **Approximately 65 blocks**
  - **Represent corrugation using a percentile of block RMS**
    - **65th percentile – skews to median**
    - **95th percentile – skews to max**
    - **85th percentile** RCI_{85}

Track-related considerations

- Defining segment length according to geometry (tangent, spiral, curve)
- Differentiating low and high rails on curves
- Using different lateral sensor positions (25, 30, 35, and 40-mm from gauge face)
- Defining segments based on track structure (ballasted, direct fixation)

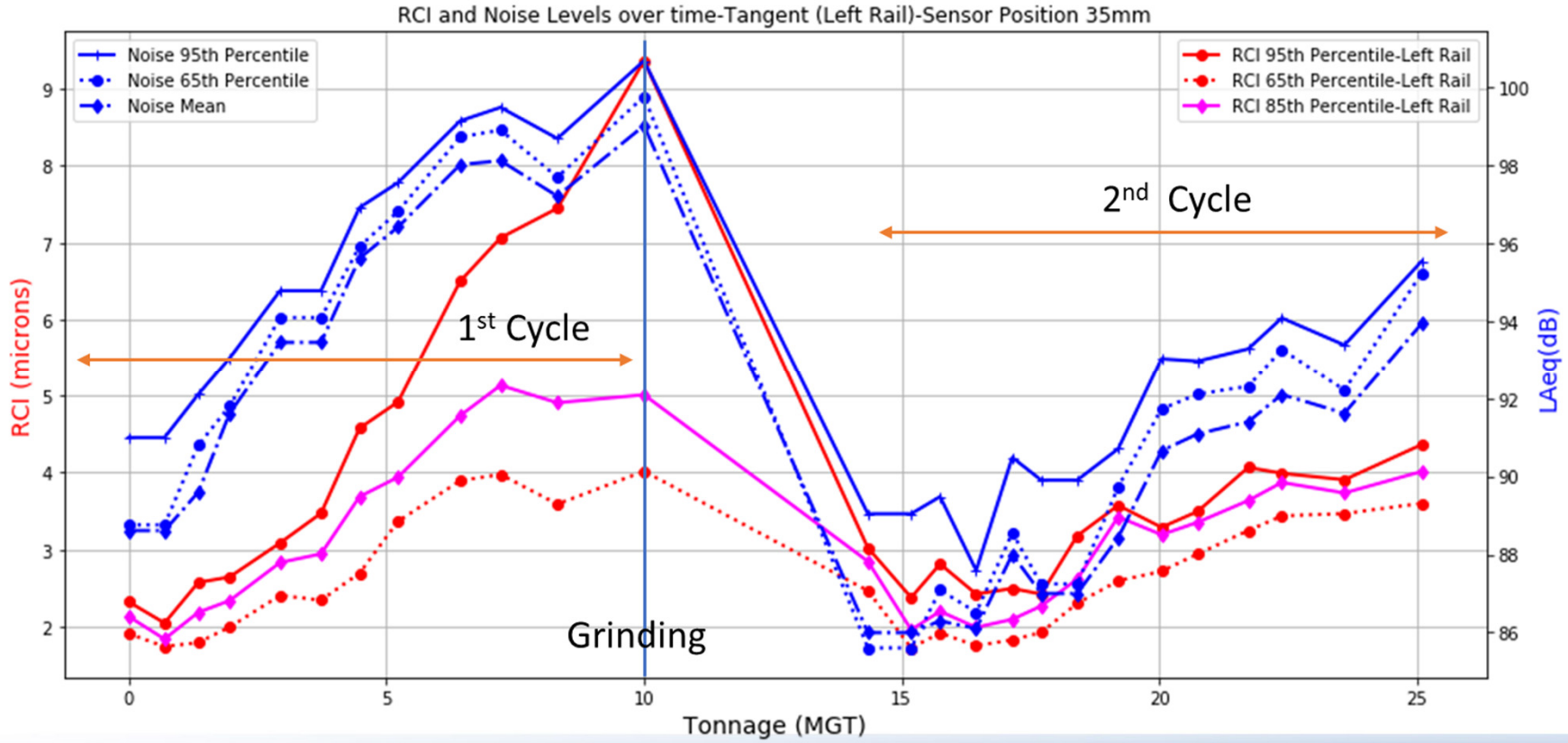


Sampling frequency and timing

When should corrugation be measured?

- **Periodically as a function of time**
- **Periodically as a function of MGT**
- **“Measure-grind-measure” approach (if there is a need to evaluate grind effectiveness)**

Data integration (wayside noise)



Conclusion

- Corrugation is pervasive and persistent
- Prevention begins with data to inform intervention decisions
- A corrugation data collection program requires careful sampling design and commitment