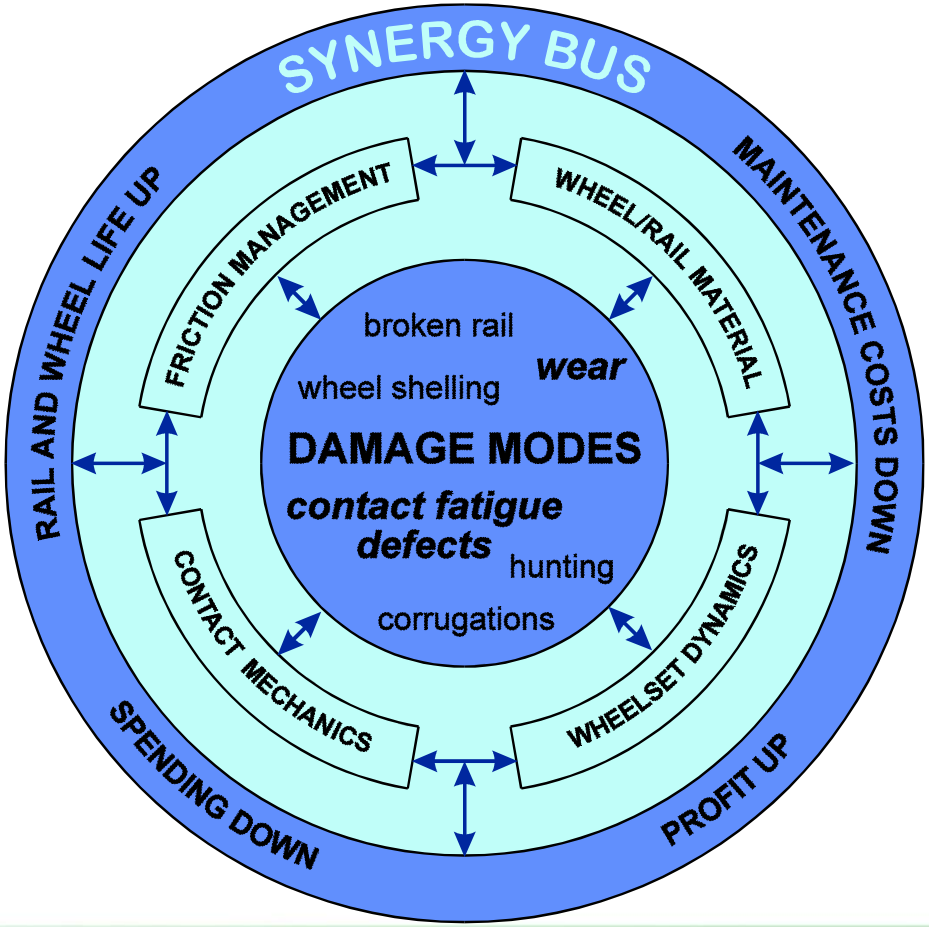
Maintaining the optimized wheel/rail interface

Eric E. Magel

Principal Engineer, NRC Canada

OWRI

1. Contact Mechanics
2. Friction Management
3. Wheel/Rail Material
4. Wheelset Dynamics



Examples

- Adopting a new wheel profile
- New rail or vehicle procurement
- Implementing a rail grinding program
- Improving lubrication
- Adopting (TOR) friction management
- Noise or vibration abatement

Once you have the optimized wheel/rail profile designs, friction management etc. how do you implement and maintain it?

YOU MUST MEASURE, MONITOR AND CORRECT

Measure, Monitor and Correct

- What is the driving concern/motivation?
  - Examples: Wheel and/or rail wear, wheel-rail noise, broken rails
- Set Goals – what does success look like?
- Determine baseline, establish key performance indicators

Must (acquire and) employ the proper tools

Outline

1. Rail and wheel profiles
2. Rail and wheel surface condition
3. Treating damaged rails and wheels
4. Friction

Metallurgy

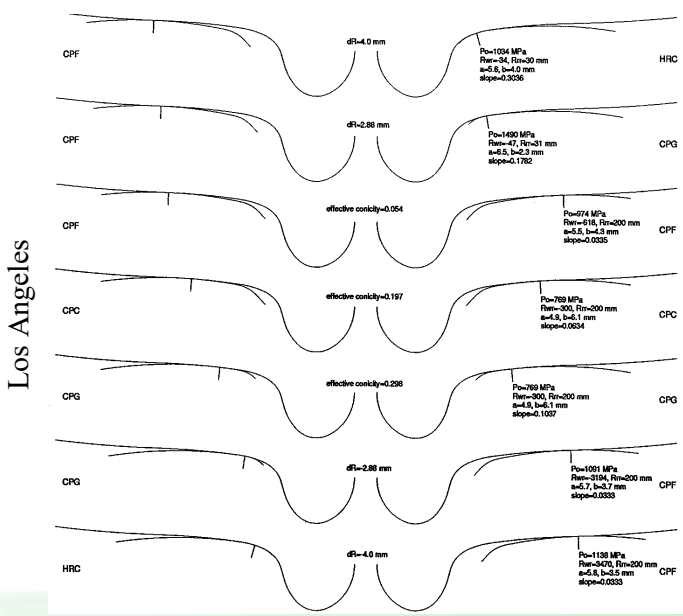
Vehicle performance

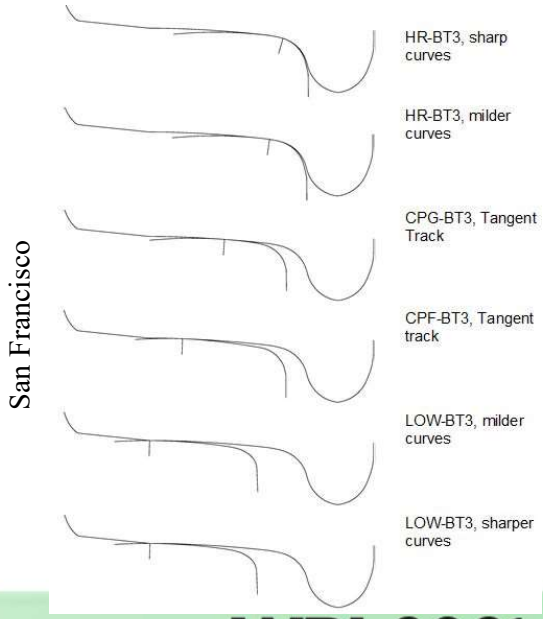
Track Performance

1. RAIL AND WHEEL PROFILES

Rail profiles

- Some railroads have a single shape, others have multiple rail profiles



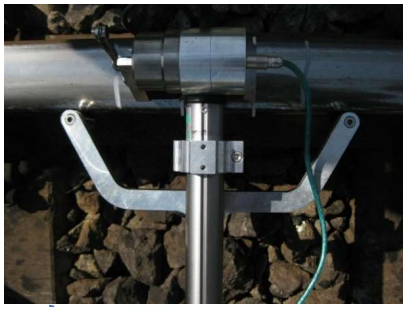


Managing rail profiles

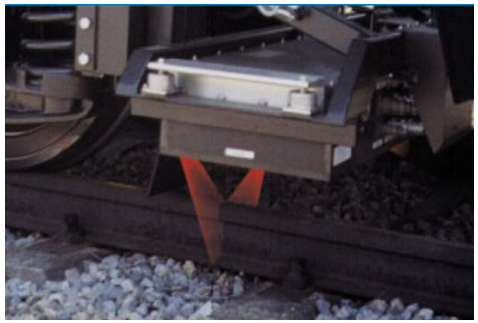
- Choose/Install rail that is close to initial shape
  - 14” => 12” => 10” => 8” crown radius
  - RE115-8, RE136-8, RE141

- Rail profile (usually pre-grind) survey

Measuring rail profiles



https://www.nextsense-worldwide.com/en/industries/railway/rail-cross-profile-measurement.html



MiniProf™

ftp://ftp.greenwood.dk/miniprof/pdf/MiniProf-BT-brochure-2015.pdf

Profile Quality Index

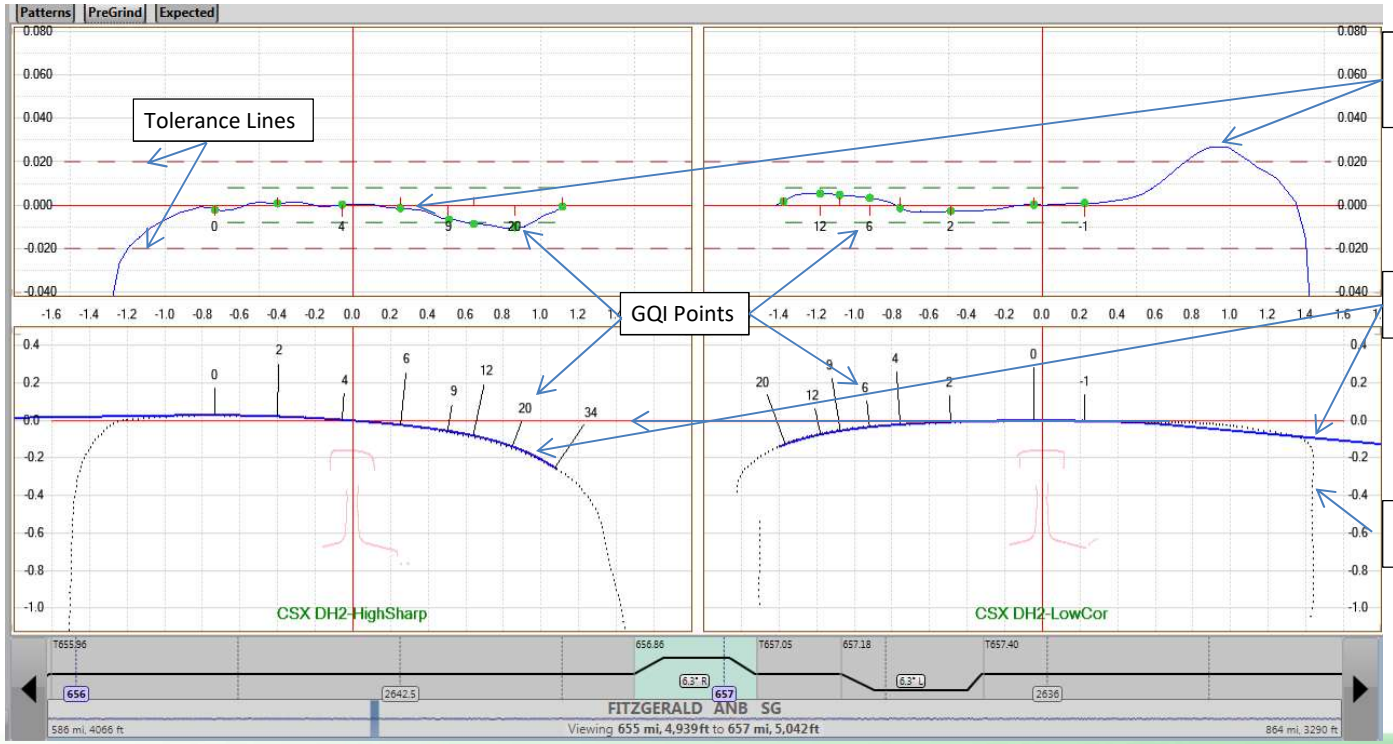
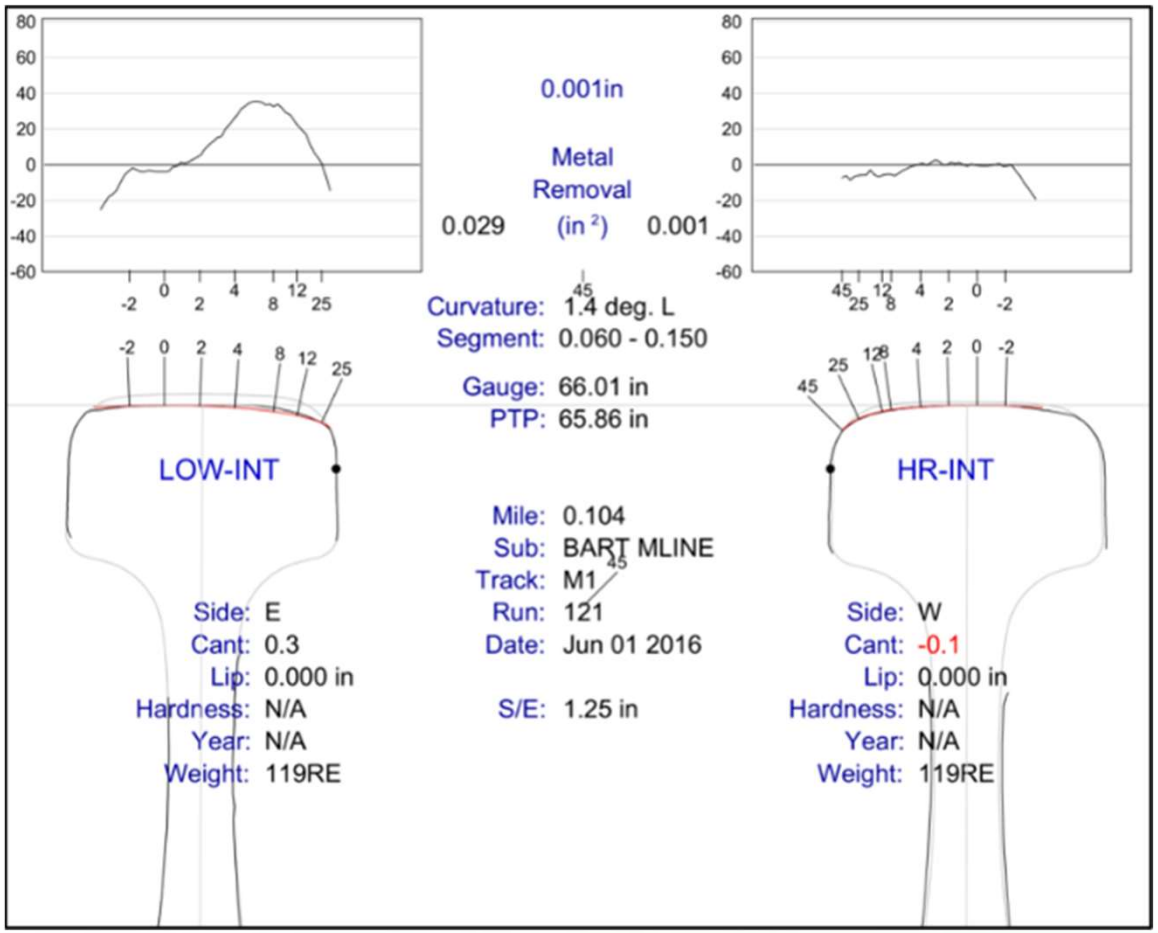
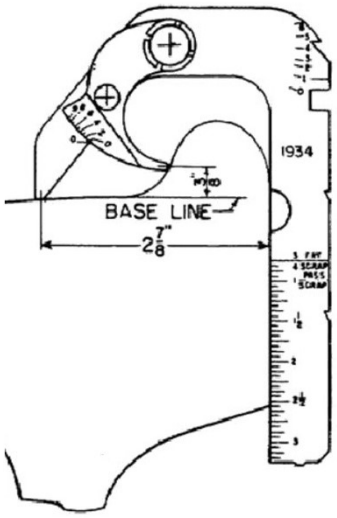


Image courtesy of LORAM Maintenance of Way, Inc.


0.001in
Metal
Removal
0.029 (in²) 0.001
Curvature: 1.4 deg. L
Segment: 0.060 - 0.150
Gauge: 66.01 in
PTP: 65.86 in
LOW-INT
HR-INT
Mile: 0.104
Sub: BART MLINE
Track: M1
Run: 121
Date: Jun 01 2016
S/E: 1.25 in
Side: E
Cant: 0.3
Lip: 0.000 in
Hardness: N/A
Year: N/A
Weight: 119RE
Side: W
Cant: -0.1
Lip: 0.000 in
Hardness: N/A
Year: N/A
Weight: 119RE

Wheel Profile Measurement

Hand gauges, digital instruments



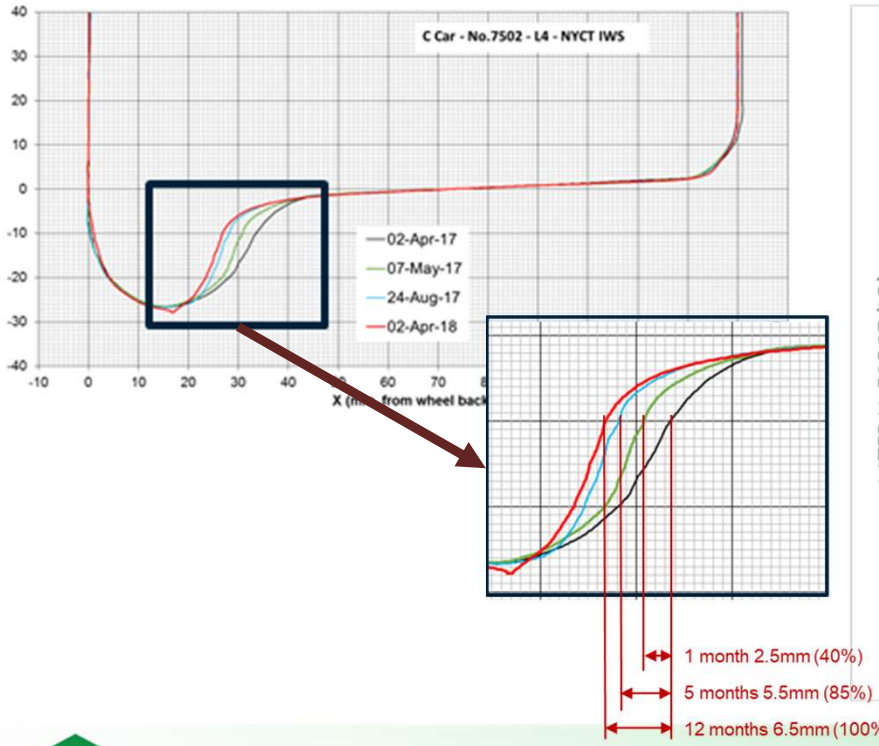
ftp://ftp.greenwood.dk/miniprof/pdf/MiniProf-Wheel.pdf

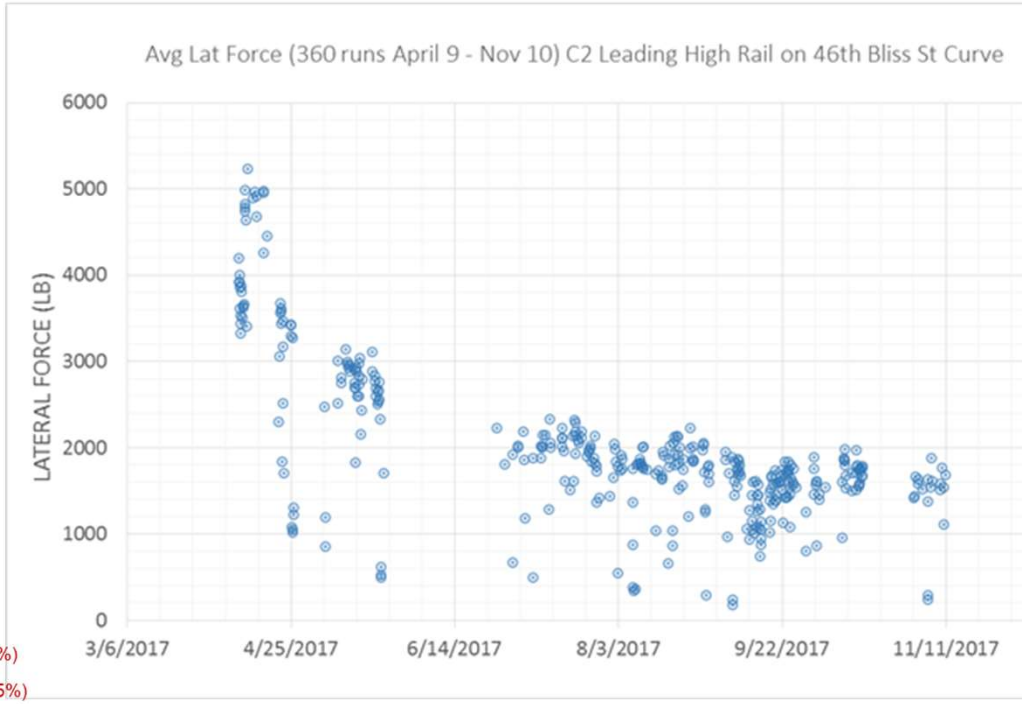
KLD LABS
MEASUREMENT TECHNOLOGIES

(Wear) Limits

- Flange height and width
- Rim thickness
- Hollowing
- Wheel(set) diameter mismatch
- Ride quality

Trending the Effect of Wheel Wear





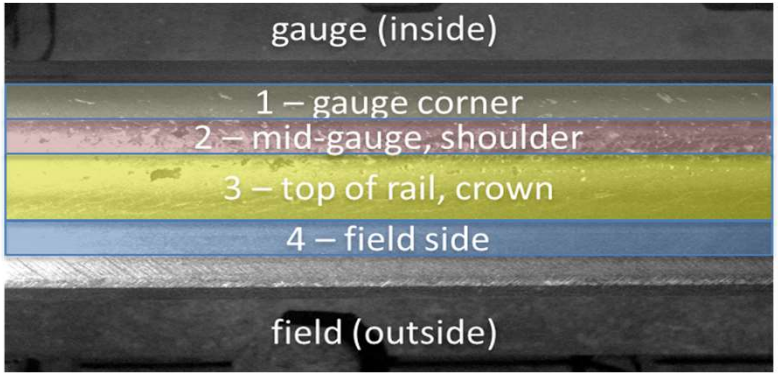
2. RAIL AND WHEEL SURFACE CONDITION

Rail surface condition issues

- Rolling Contact Fatigue (RCF): Visual, magnetic particle, dye penetrant, electromagnetic
- Wheel burns
- Corrugation: Visual, Straight edge, CAT (corrugation analysis trolley), accelerometers etc.
- Noise and/or vibration

Magnetic particle enhancement

Surface Condition Scoring



Surface Quality Index (SQI) with corrective actions

Category	Description
0	None
1	barely perceptible, but clearly regular pattern (preventive grinding < 0.5).
2	clear, distinct individual cracks - but no pitting at tip (maintenance, depth < 1.0 mm)
3	clear cracking, pits up to 4 mm diam (corrective grinding 1.0-2.5 mm deep)
4	pitting greater than 4mm < 10 mm (preventive gradual, up to 3.5 mm deep)
5	isolated pitting/shelling/spalling > 10, diam (up to 5 mm deep)
6	Shelling/spalling: regular pitting, >10mm diam (busted, near impossible to catch up on)
7	Shelling/spalling: any defect > 16 mm diam, >20mm length

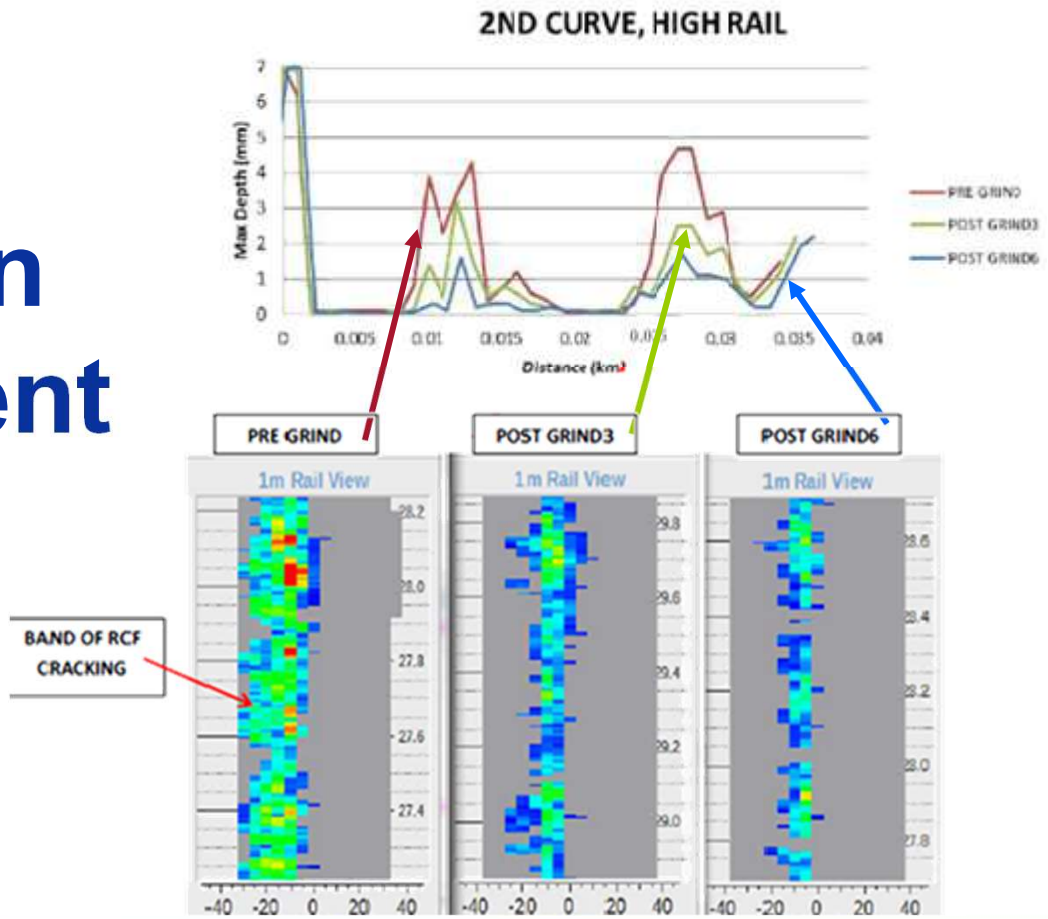
Electromagnetic Walking Sticks

Rohmann Draisine
(eddy current)

Sperry walking stick
(eddy current)

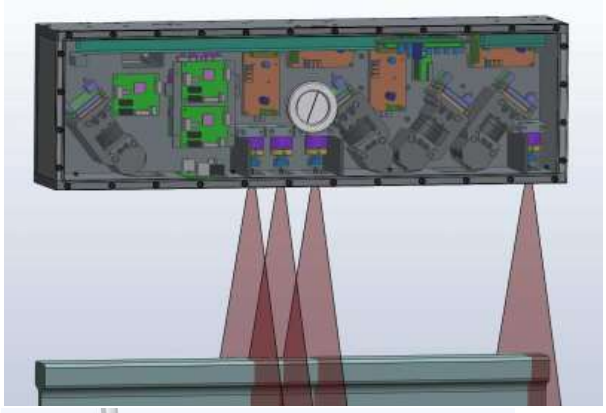
MRX RSCM
(magnetic flux)

Surface Condition Assessment (MRX)



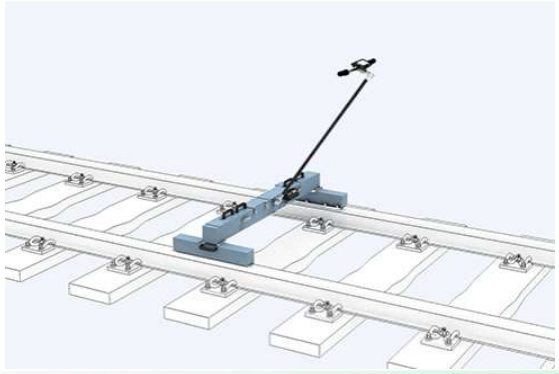
Corrugation measuring approaches

Corrugation Analysis Trolley



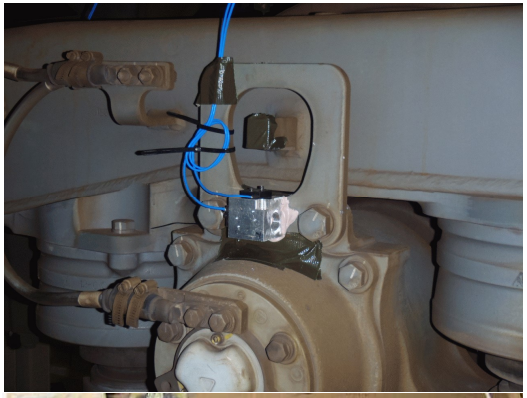
Technogamma RCMS
“3-point versine system”

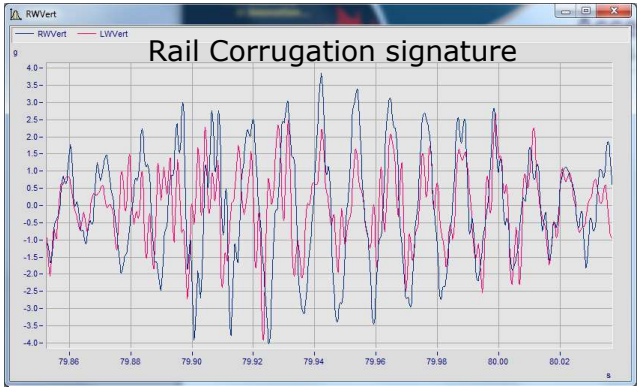
Mermec: Technoline
Uses eddy current displacement transducers

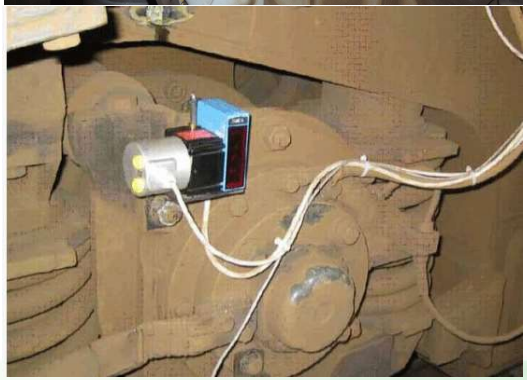


Wheelset displacement or axlebox accelerometers

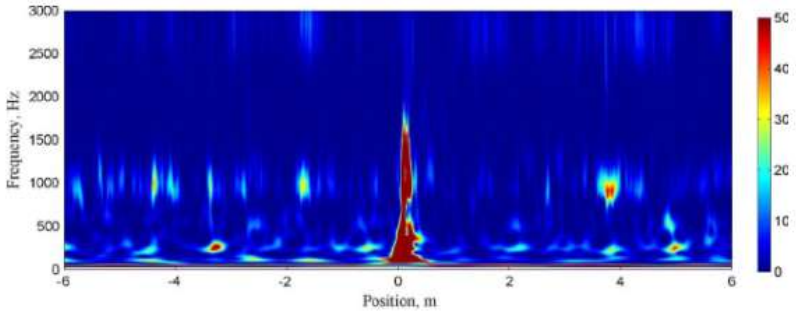
Accelerometer Based Systems







https://www.tudelft.nl/kennisvalorisatie/investeren-in-kennis/octrooien/selectie-van-tu-delft-patent-portfolio/detection-method-for-squats/

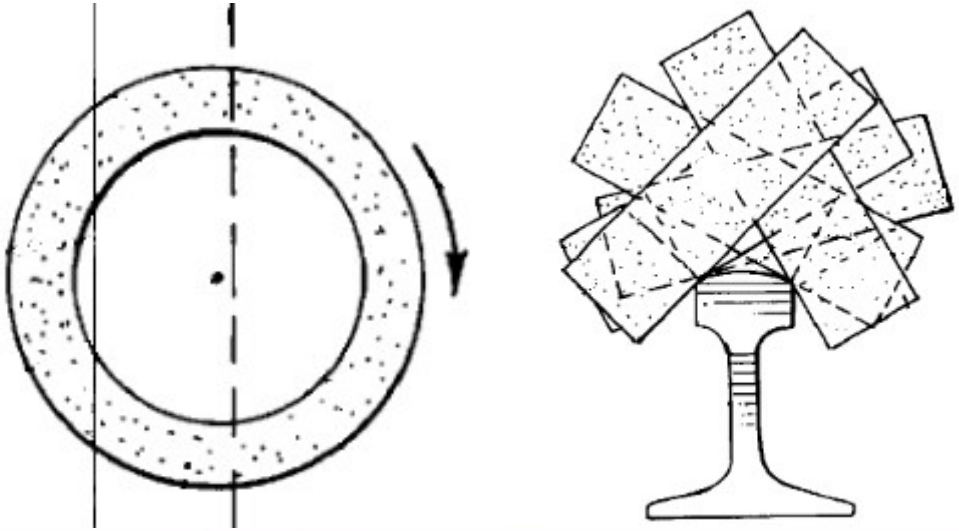


https://www.researchgate.net/publication/265085881_Automatic_Detection_of_Squats_in_Railway_Infrastructure/figures

3. TREATING DAMAGED WHEELS AND RAILS

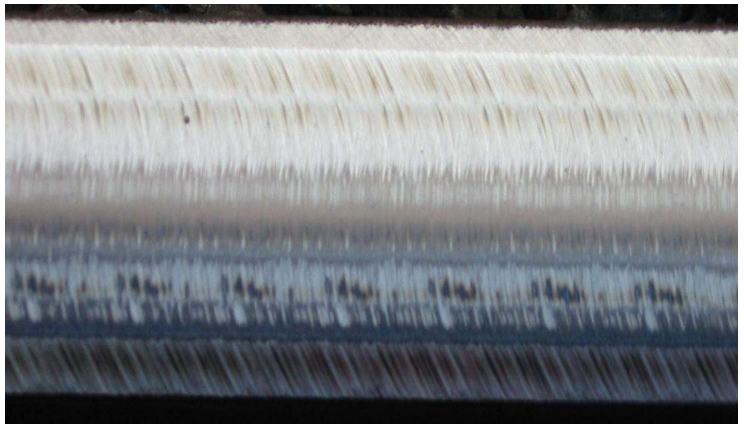
Vertical Spindle Grinding

Type 2 rail grinding



Surface Finish to Avoid

Grinding stone chatter
(pressure control)



High grinding pressure causing large grinding facets.
Blueing from low grinding pressure.

Rail Milling Technology

- Non-abrasive rotary cutting process
  - Chips cut out of surface
  - Heat transfer into chips and tool
- Different machine types and sizes available
- Widely used in Europe, Asia and Australia
- Applied chiefly for corrective maintenance

Rail grinding strategy

Corrective (e.g. >60 MGT)

- Less frequent
- More metal removed each cycle
- Less track covered
- Rail profiles deteriorate
- Surface damage often significant

Preventive (e.g. 20 MGT)

- More frequent
- Less metal removed each cycle
- Covers the system quicker, maybe several times / year
- Rail maintained so always in good shape

Preventive Gradual (e.g. 20 MGT)

- Correct shape first, deal with RCF second
- Almost same interval as preventive
- Allow several cycles to catch up on poor rail.

Maintaining Wheels

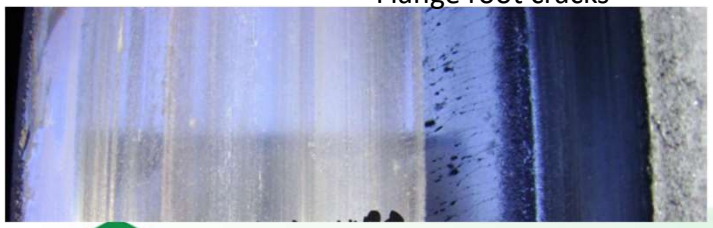
- Surface condition
  - Rolling contact fatigue (cracking, shelling)
  - Thermal cracking
  - Out of round and polygonization
  - Wheel flats

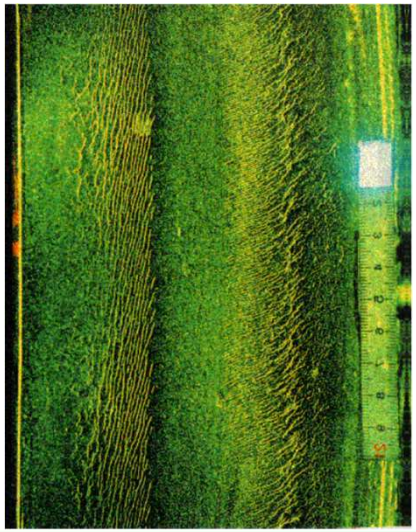
Wheel Surface Condition

Visual, eddy current

Field side cracks

Flange root cracks





Magnetic fluorescent particle inspection

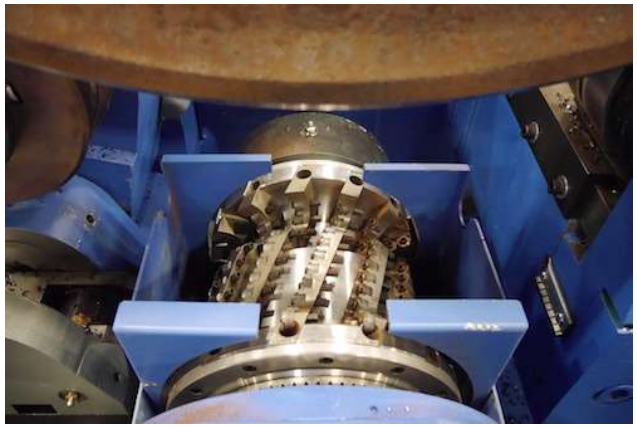
https://www.railwaygazette.com/news/single-view/view/wheel-surface-crack-measurement-device-could-offer-25-cost-savings.html

Wheel retruing machines

Lathe

https://railways.danobatgroup.com/en/underfloor-wheel-lathe

Milling



https://smtgroup.com/en/railway-wheel-shop-equipment/underfloor-technology/underfloor-wheel-truing-machine-stanray

Wheel retruing machines

Lathe

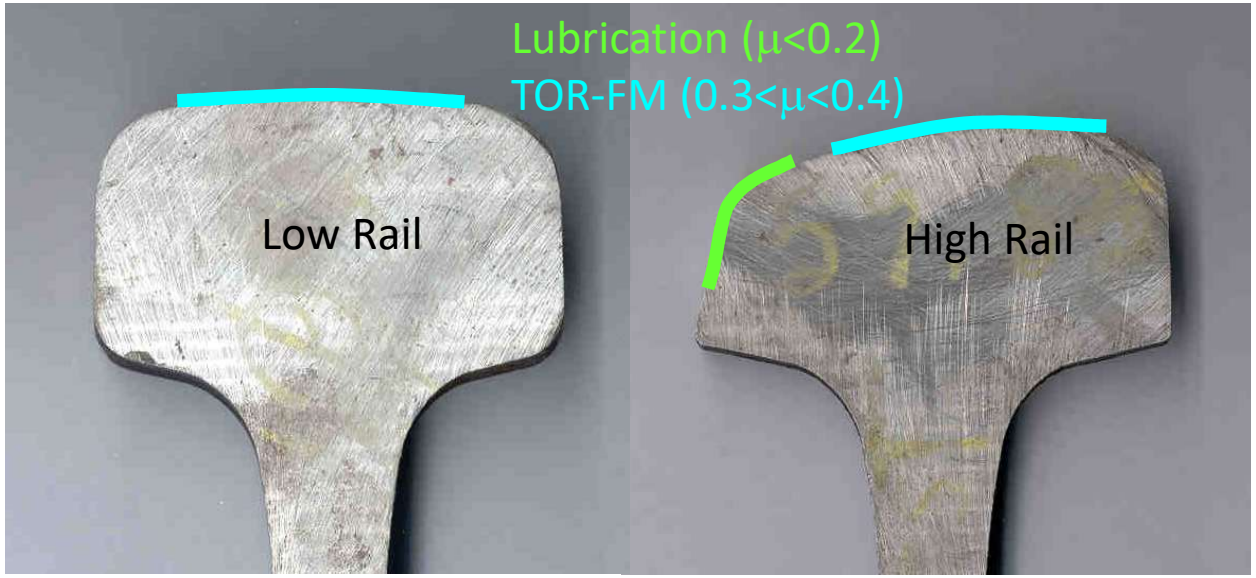
- Template or Programmable
  - Good flexibility re shape
- Single point cutting tool
- Lighter cuts
- Fine surface possible
- More tooling
- More experience required

Milling Machine

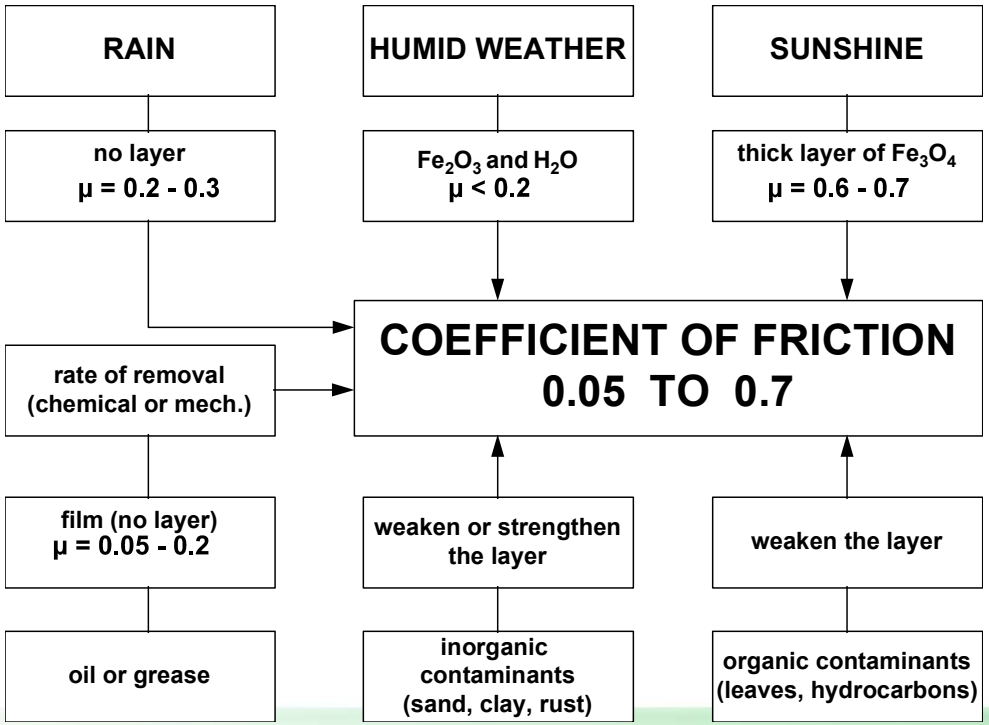
- Cutter head ≡ 1 profile
- Multiple blades with replaceable carbide inserts
- Large cuts possible, faster
- Relatively rough surface
- Requires less experienced operators

4. FRICTION MANAGEMENT

Controlling W/R Friction
2 zones of concern

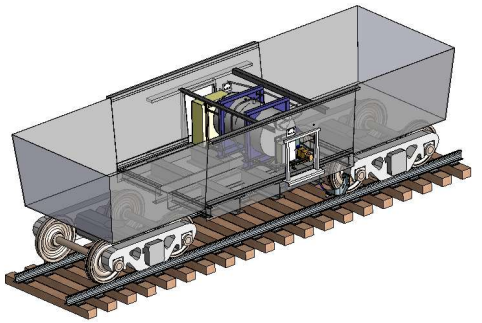


COF – TOR contact



Systems for Managing Friction

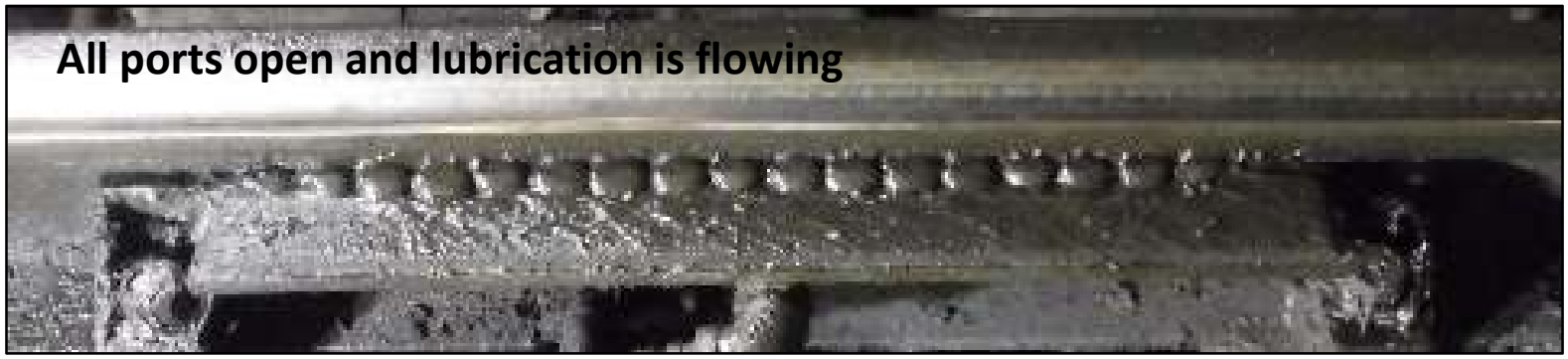
- Wayside
  - Electric sensors, pumps
  - Dispenser bars
- Vehicle borne
  - Solid sticks
  - Spray systems
  - Locomotive dispensing
  - Revenue car



From https://www.lbfoster.com/en/market-segments/rail-technologies/solutions/friction-management/technical-support

http://evolution.skf.com/wheel-flange-lubrication-for-railway-systems-3/

Lubrication



Lubrication

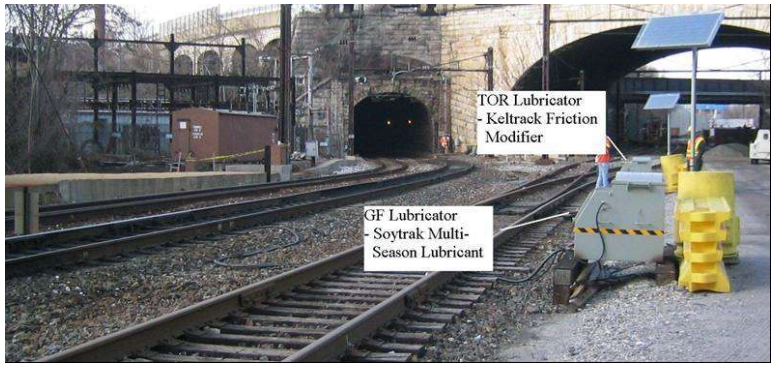
- Wayside Lubricators: criteria for a successful wayside implementation
  - Placement on track (tangent ahead of curve)
  - Bar designs (length, #ports), positive displacement pumps, minimize cavitation (e.g. stir paddles), remote monitoring
  - Selection of grease : summer versus winter
  - Dealing with difficult areas, e.g. embedded track

(TOR) friction management

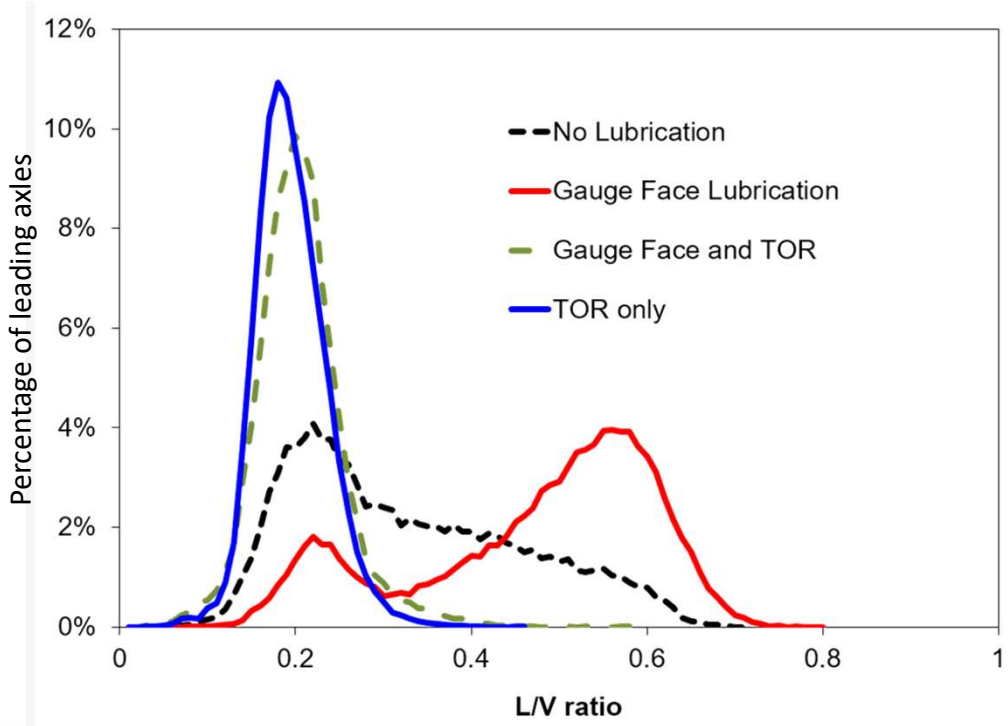
- Product used
  - oil or water based?
  - Solid stick
- Application technique
- Monitoring and maintenance of hardware systems

Friction Measurement

Effectiveness of Friction Management



From P. Sroba et al, Testing of Rail Friction Management on the 377.2 Baltimore Curve, NRC report #54-A62209-T11-2-AUG05



Regular inspection and good record keeping

… maintainers who kept detailed wheel condition and maintenance records, and actively managed and optimised their maintenance practices, achieved significantly better wheel life than those who did not.

RSSB summary report T963: Improving wheelset life by better understanding the causes of wheel damage, July 2019

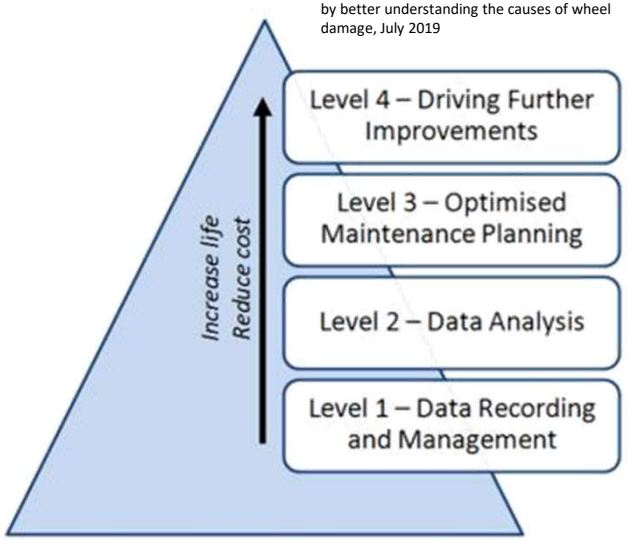
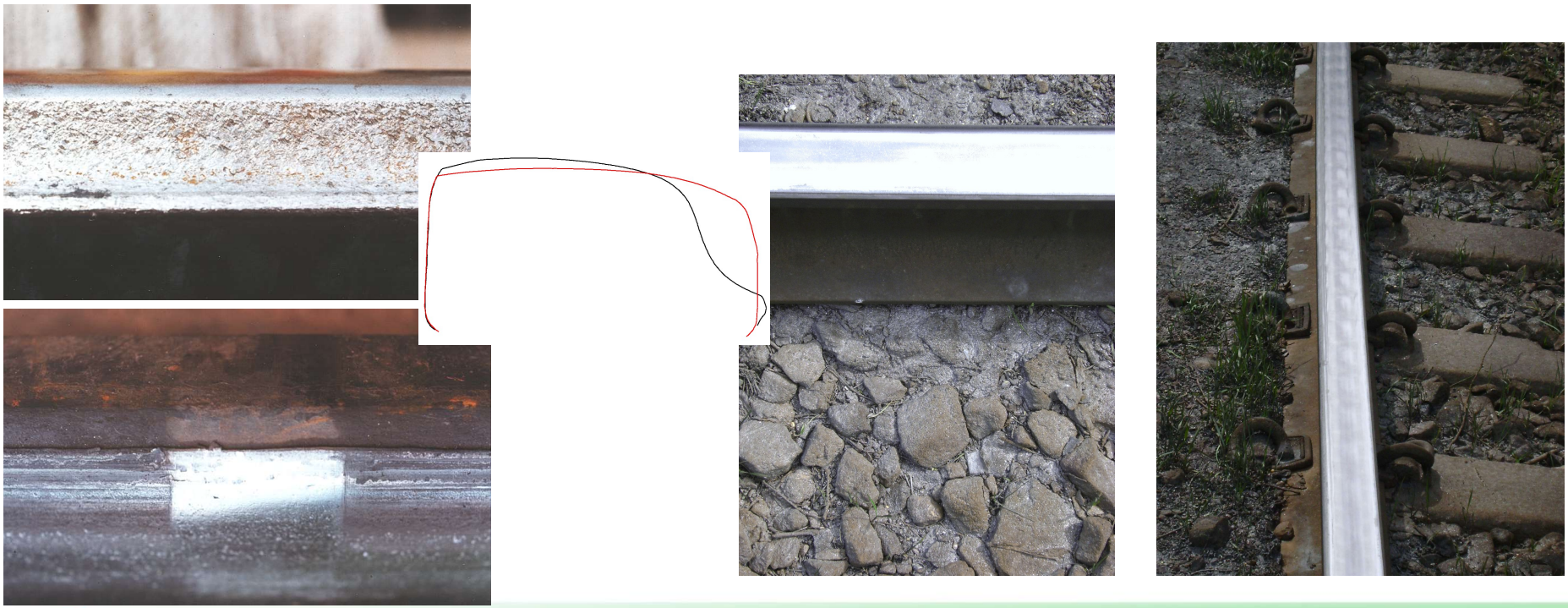


Figure 3 - Management and optimisation of wheelset life

The rail tells the story



Maintaining wheel/rail performance

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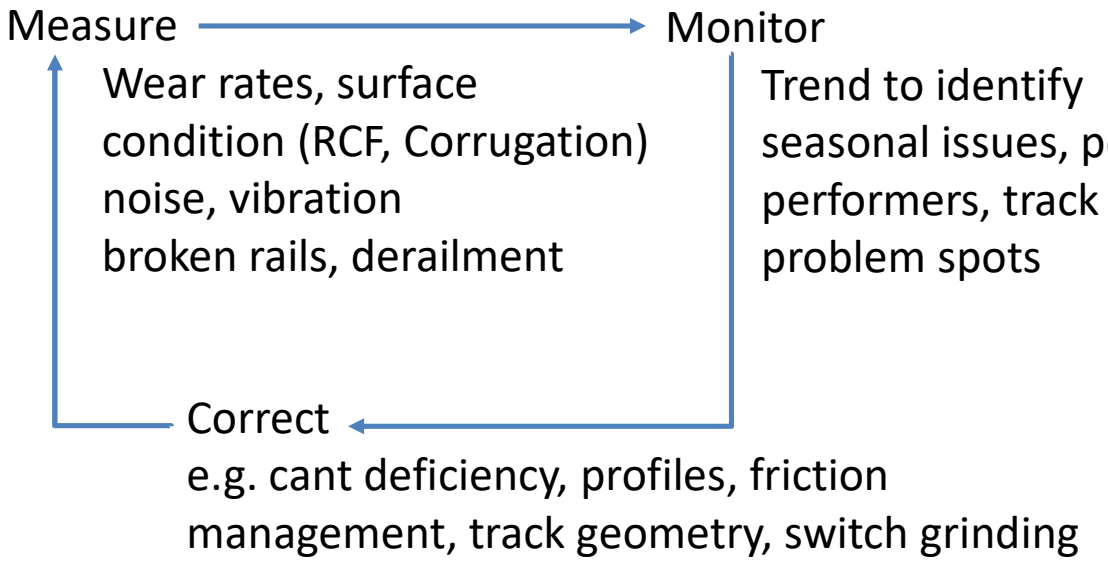

Acknowledgements

- Colleagues within NRC
  - Rob Caldwell, Daniel Szablewski, Yan Liu
- Many colleagues within the rail industry
  - Amtrak, ARM, Canadian Pacific, ENSCO, FRA, LB Foster, KLD, LORAM, Plasser, Rohmann, SFU …

Thank You

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