Integrated rail maintenance for maximizing rail and track life

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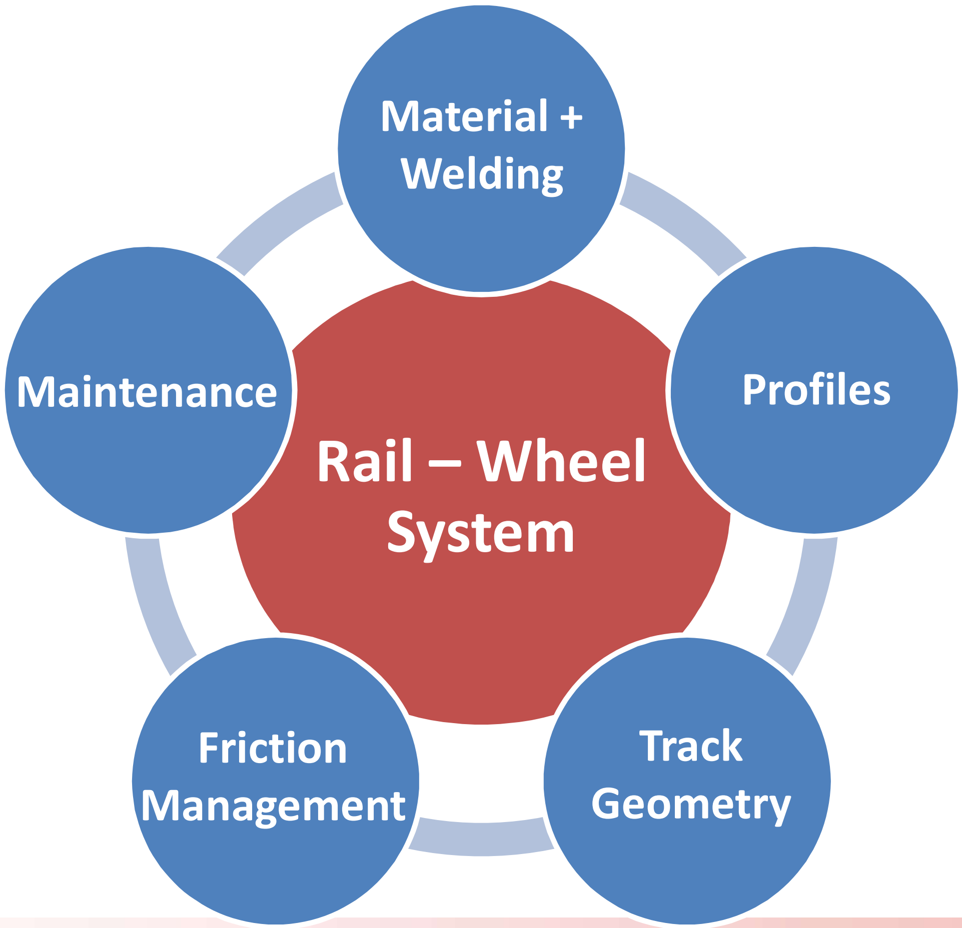
- Summary


Material +
Welding
Maintenance
Profiles
Rail – Wheel
System
Friction
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Track
Geometry

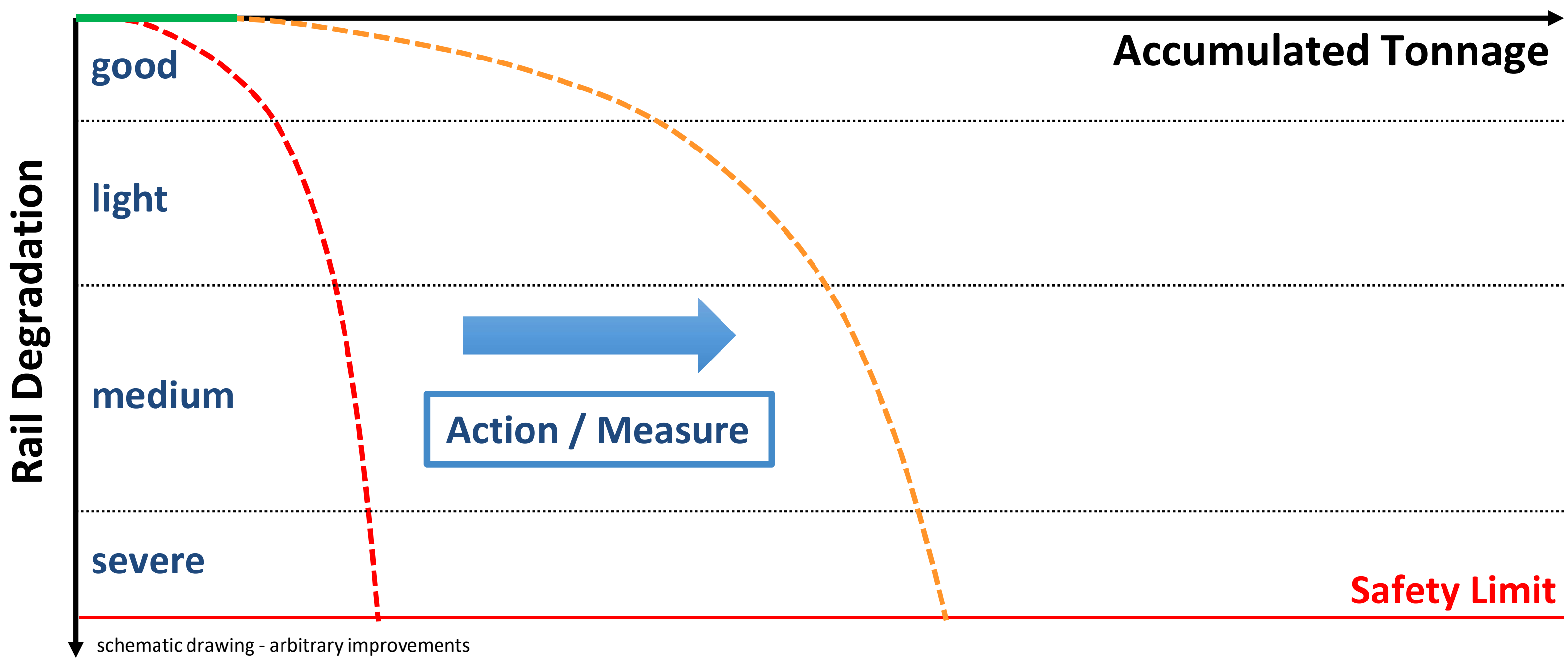
Rail Material

- Rail grade selection
  - Premium (heat treated) rails
  - Optimised material structure for advanced behaviour
  - Improved damage and wear resistance
    - Rail life extension
- Delay rail degradation

Quelle: voestalpine, WRI 2012 Konferenz

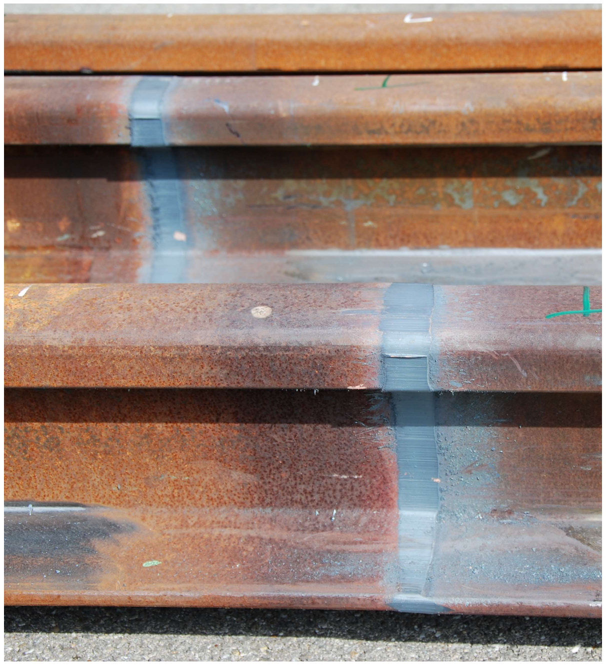
Quelle: voestalpine, SFT 2017

Delay Rail Degradation



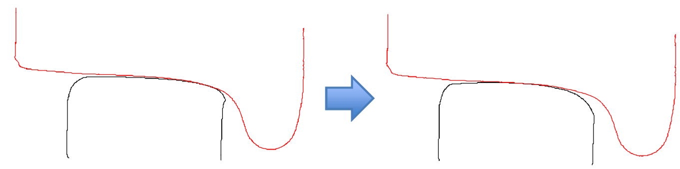
Rail Welding Technology

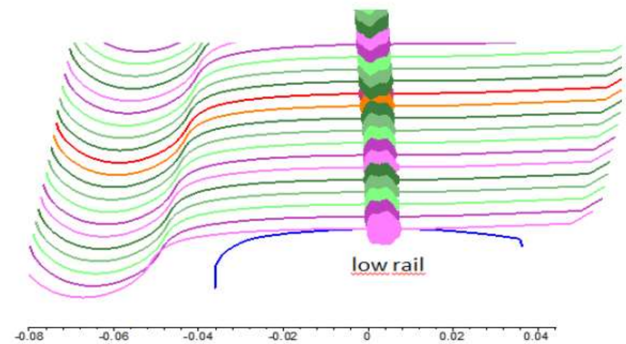
- Every connection is a discontinuity
- Welding technologies:
  - Thermite welding
  - Flash butt welding
- Goal: long lasting rail connection that has similar / same material properties as the rail material
  - Ideally: joint not “felt / seen” by passing train
- Prevention of premature damage on welds



Rail / Wheel Profiles

- Optimised profiles
- Reduced contact pressure
- Improved steering (curves) and stability (tangent)
  - Reduced tangential forces and flanging
  - No hunting in tangent track
- Delay rail degradation





A. Jörg, R. Stock, S. Scheriau, H.P. Brantner, B. Knoll, M. Mach, W. Daves. The Squat Condition of Rail Materials - a Novel Approach to Squat Prevention. Proceedings of CM2015 conference.

Track Geometry

- Tangent, transition, curve
- Gauge, alignment (horizontal), profile (vertical), crosslevel
- Quality of subsoil, ballast, sleepers, rails
- Low track quality – high (dynamic) forces
- Optimised track quality – delay of degradation

Friction Management

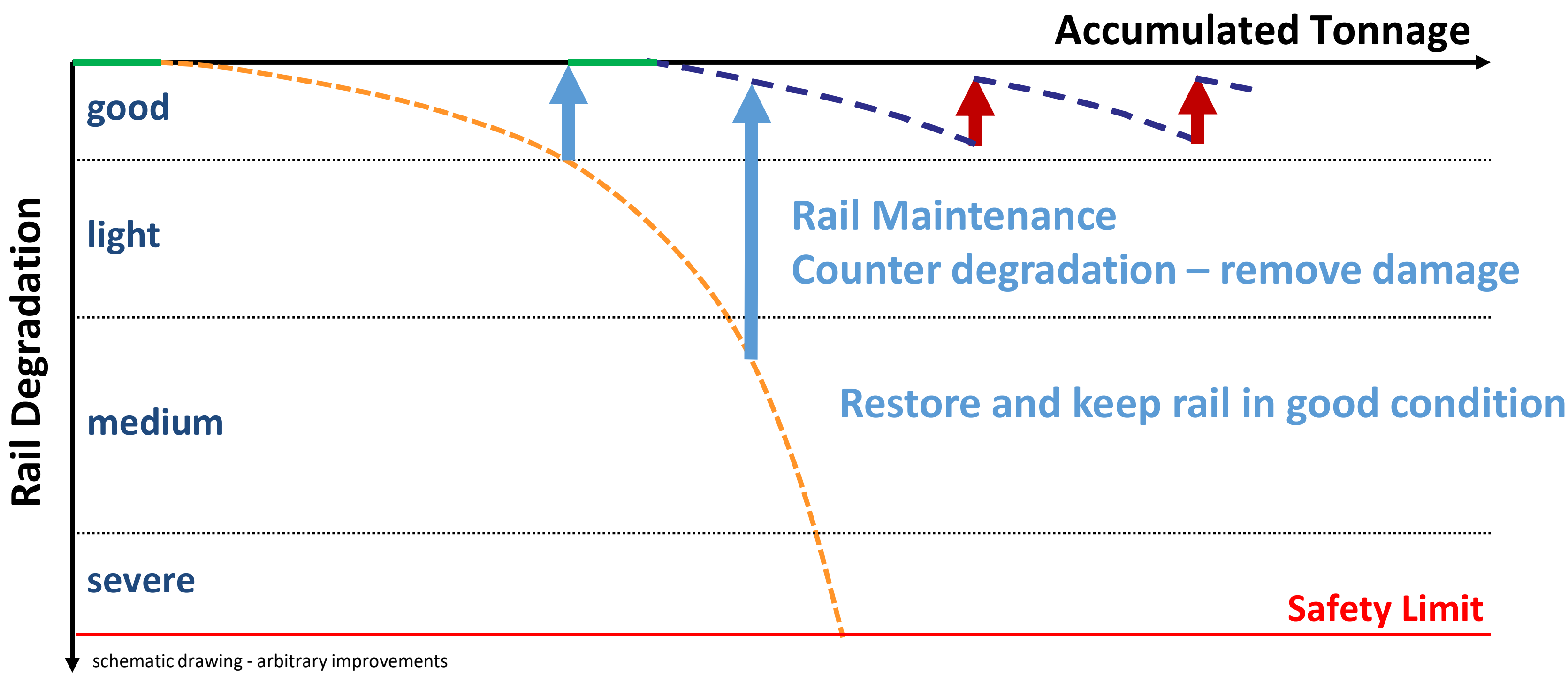
- Friction Management
  - GF & TOR friction control
  - Improved steering
  - Reduced (tangential) contact stresses
  - Reduced plastic flow, wear and RCF
- Delay formation of damage

Photo by L.B. Foster Rail Technologies

Rail Maintenance

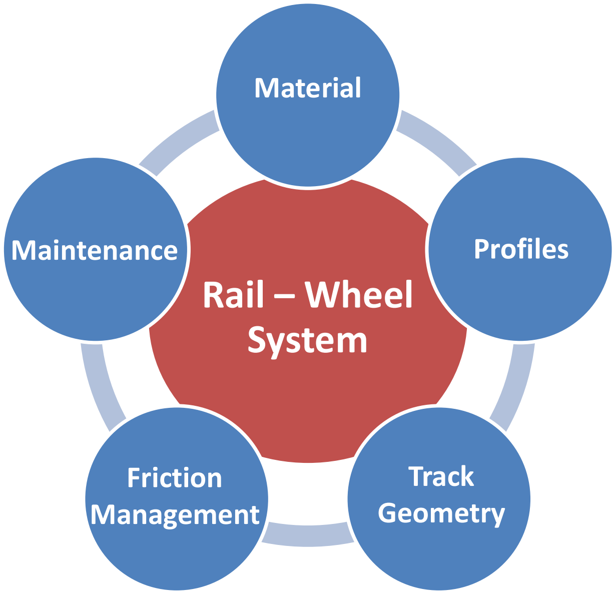
- Rail Maintenance
  - Grinding and Milling
  - Corrective/regenerative: reset/restore your rail condition
  - Preventive / Predictive: keep your rail in healthy condition
- Remove damage and keep profile in "shape"

Restore Rail Condition



Integrated Maintenance

- Apply a consequent system approach
- Combine Rail Maintenance with other measures
  - Key factor as it can remove damage
- Maximum system life



Example 1 - Acknowledgement

- Special Thanks to:
  - Mathias Asplund / Trafikverket
  - Wolfgang Schöch / retired Speno
  - Alexander Baltzewitisch / Speno
  - Rainer Hochfellner / voestalpine

- Literature:

[1] M. Asplund, S. M. Famurewa, and W. Schoech, "A Nordic heavy haul experience and best practices," *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, vol. 231, no. 7, pp. 794–804, Aug. 2017, doi: 10.1177/0954409717699468.
[2] M. Asplund, S. A. Khan, and T. Nordmark, "Improved wheel-rail system of Sweden's iron ore line," in *Procedings of the 11th International Heavy Haul Conference (IHHA 2017)*, Cape Town, 2017, pp. 759–766.
[3] M. Asplund and W. Schoech, "Cyclic and special wear-adapted rail profile grinding - experience gained on Malmbanan heavy-haul railway, and scope for implementation elsewhere.," Rail Engineering International, vol. Edition 2018, no. 2, pp. 10–14, 2018.

Example 1: Iron Ore Line

- Northern Sweden and Norway
- Iron Ore traffic mixed with passenger and freight trains
- 32.5t axle load / 30 MGT per year
- Train: 68 cars, 1 double loco
- Electrified, mountainous line
- Extreme weather: wet and dry, cold (-40°C) and hot (30°C)

Photo: Speno

Initial Conditions

- Track renewal between 2006 and 2009
  - R350LHT heat treated (premium) rails
  - Concrete sleepers, elastic fasteners
- As rolled profile (BV 50/60E1)
- Given wheel profiles for locomotives and ore cars

Photo: Kabelleger / David Gubler (http://www.bahnbilder.ch), CC BY-SA 3.0 <http://creativecommons.org/licenses/by-sa/3.0/>, via Wikimedia Commons

Initial Challenges

- Wear and RCF of rails
  - Gauge widening in sharp curves
- Factors:
  - Increased traffic, axle loads and length of trains
  - Climate conditions
  - Less time for maintenance
- Cyclic rail grinding
- GF lubrication for curves R<650m

Photo: [1]

Monitoring Program

- Without problem quantification no solution can be found!
- Close monitoring program
  - rail and wheel profiles
  - cracks by eddy current
  - track geometry
- At least two times per year measured

Photo: [3]

Rail Grade Optimisation

- R350 LHT profile installed between 2006-2009
- R370CrHT (370 LHT) was installed in test curves
  - Less wear but not enough RCF reduction to extend grinding
- R400HT test program (in progress)
  - Potentially safe one grinding cycle
- Welding not a problem

Photo: Speno

Rail Profiles - I

- MB1 profile introduced to combat RCF (high rail)
  - Curves < 650m radius
- MB4 as fine-tuning of MB1 (less undercutting at GC)
  - Tangent track
- MB4 also introduced for switches

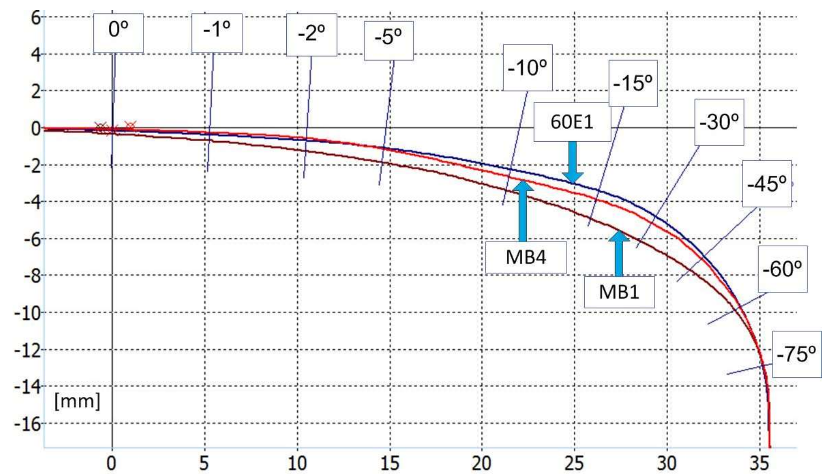


Photo: [1]

Rail Profiles - II

- Introduction on MB6 for low rail
  - Based on hollow worn wheels
  - Wider low rail contact area and less low rail damage
  - Curves > 650m and gauge widening areas

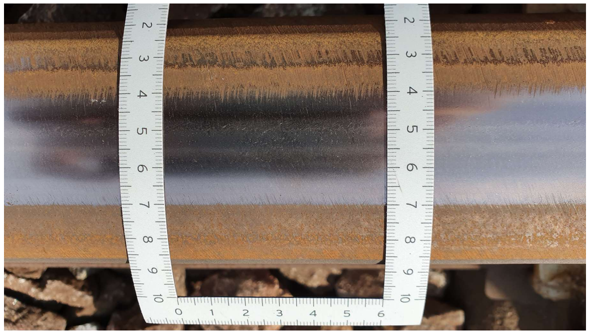


Photo: Speno

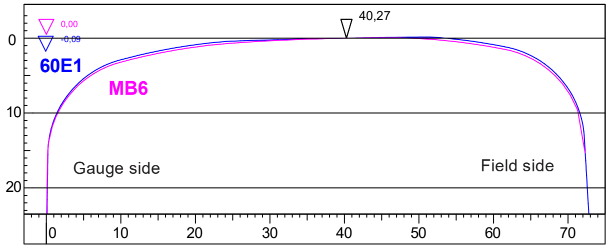


Photo: Speno

Wheel profiles - I

- Wagon wheels:
  - Good performance
  - Reprofiling: 180,000 – 200,000 km
- Failure modes:
  - 55% RCF
  - 45% wear
- Locomotive wheels
  - Problem: reprofiling 25k – 110 kkm

Wheel profiles - II

- Locomotive wheels – different damage zones identified
  - Low rail / high rail / field / gauge – contact
- New locomotive wheel profile developed: WPLX5V2
- Harder wheel steels and modified electro-dynamic braking implemented

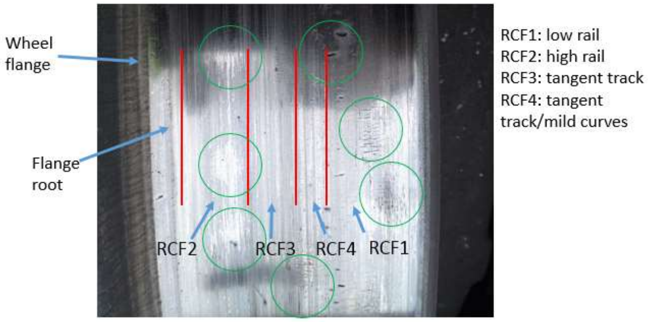


Photo: [1]

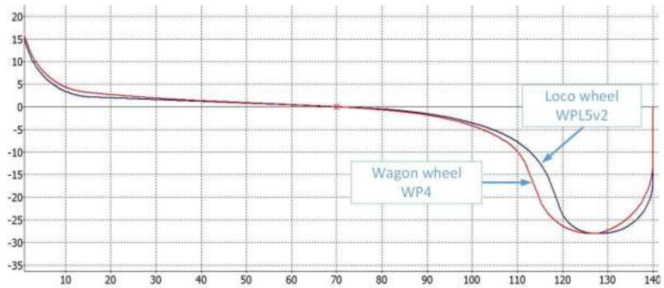


Photo: M. Asplund

Track Geometry

- In general track quality at very high level
- Certain areas: problem with gauge widening
  - Up to 2.4mm/year
  - Increased low rail RCF
- Standard Gauge: 1435mm
  - Gauge limit: 1450mm
- Introduction of MB6 rail profile
- Close monitoring with measurement cars
  - Investigation into dynamic gauge widening

Photo: Speno

TOR Friction Control

- Simulation results encouraging
- Tests with different materials and application systems (wayside)
- Harsh winter conditions
  - power problem and accessibility (maintenance)
- Challenges with carry down and according measurements
- On board better solution – no trials yet

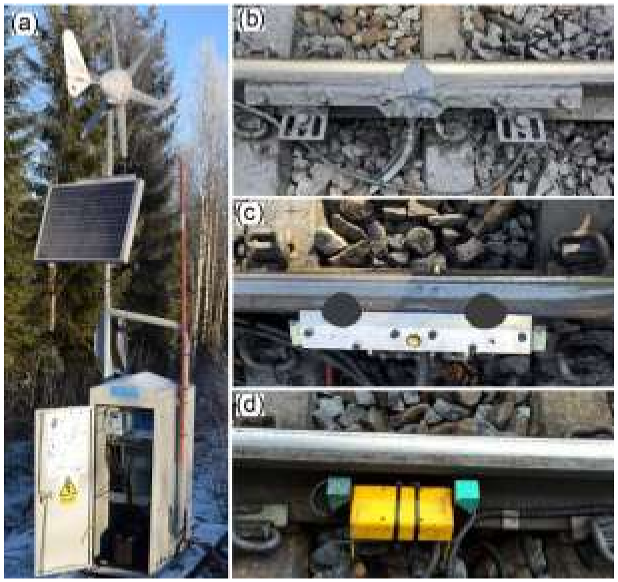


Photo: [2]

Maintenance

- Corrective grinding since 1970ies
- Annual grinding introduced 2008 (following track renewal)
- Traffic increase – denser grinding interval to combat RCF (2014)
  - 15MGT sharp / 30 MGT mild curves, 90 MGT tangent
  - “Heavy” campaign in May – curves and required tangents
  - “Light” campaign in October – curves only

Photos: [1]

Maintenance

- Target Metal removal
  - TOR: 0.2mm
  - GC/GF: achieve target profile
- Total metal removal lower than previous once-a-year campaign (GC)
- RCF well controlled – at first

Photo: Speno

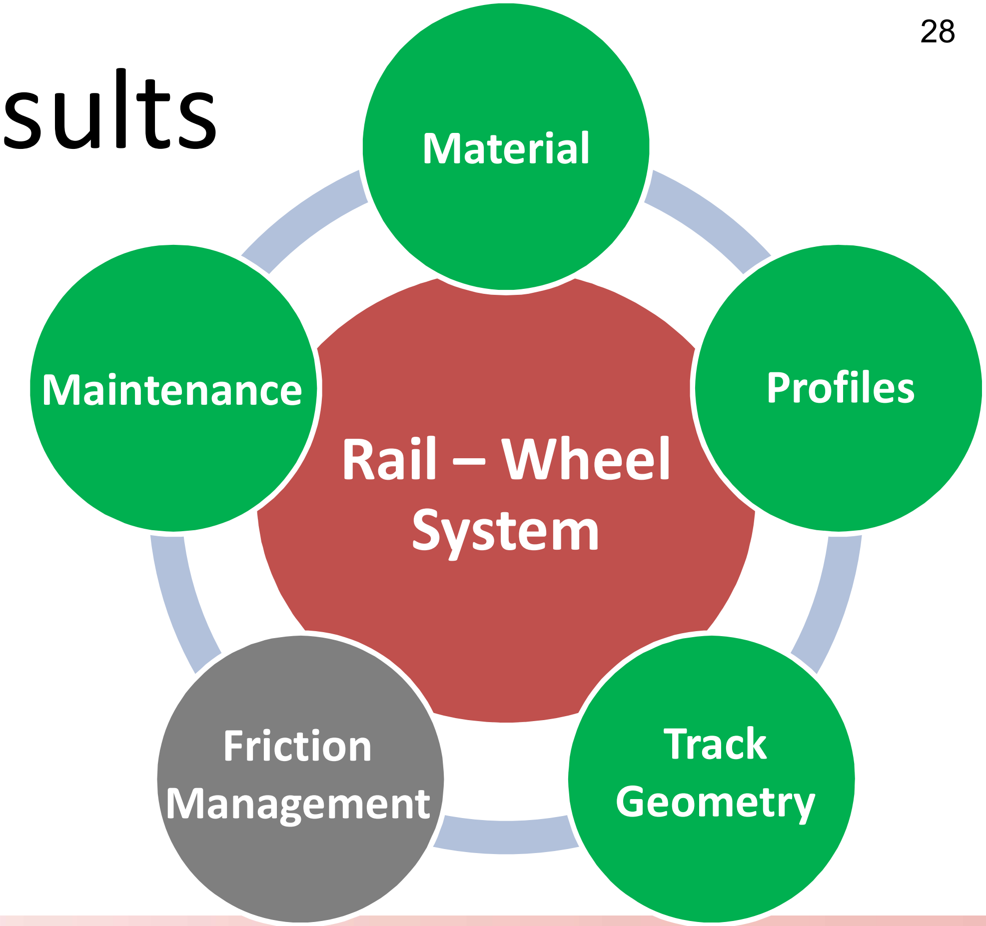
Maintenance

- Seasonality in RCF growth observed
  - Detected by Eddy current measurements
- In warm dry summer (Jun – Sep) – faster RCF development.
  - Assumed reason: friction conditions
- Adoption through switching "heavy" and "light" cycles
- Elimination of all RCF defects after grinding

Photo: [1]

Results

- Comprehensive system approach:
  - Rail and wheel life extension
  - Increased system reliability and capacity
  - Future potential for FM



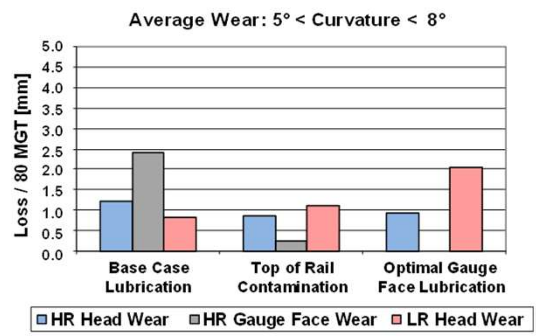
Example II – North America

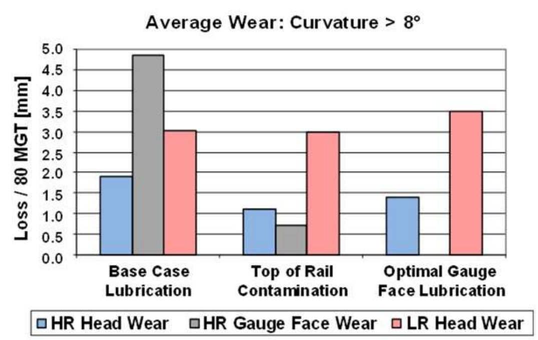
Literature:

- [1] P. Sroba, M. Roney, R. Dashko, and E. Magel, “Canadian Pacific Railway’s 100% effective lubrication initiative,” in *Proceedings of the AREMA 2001 Annual Conferences*, Chicago, USA, 2001, p. 16.
- [2] P. Sroba, R. Michael, E. Magel, and J. Kalousek, “The Evolution of Rail Grinding on Canadian Pacific Railway to Address Deep Seated Shells in 100% Effective Lubrication Territories,” Montreal, Canada, 2006.
- [3] P. Sroba, K. Oldknow, R. Dashko, and M. Roney, “Canadian Pacific Railway 100% Effective Friction Management Strategy,” in *Procedings of the 8th International Heavy Haul Conference (IHHA 2005)*, Rio de Janeiro, 2005, pp. 93–102.
- [4] M. Roney, D. T. Eadie, K. Oldknow, P. Sroba, and R. Caldwell, “Total Friction Management on Canadian Pacific,” in *Procedings of the 9th International Heavy Haul Conference (IHHA 2009)*, Shanghai, China, 2009, pp. 846–854.
- [5] M. Roney, S. Bell, S. Paradise, K. Oldknow, and J. Igwemezie, “Implementation of Distributed Power and Friction Control to Minimize the Stress State and Maximize Velocity in Canadian Pacific’s Heavy Haul/Heavy Grade Operations,” *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, vol. 224, no. 5, pp. 465–471, Sep. 2010, doi: 10.1243/09544097JRRT366.
- [6] S. Paradise, R. Stock, M. Santoro, “Friction Management and Rail Wear CPs Western Corridor: 2008 – 2016,” *Presentation at the WRI Conference 2017,* June 2017

North America/Canada

- Application of target profiles (wear, RCF) and cyclic grinding since the 1980ies
- 2001: NRC "100% effective lubrication" project at CP [1]
  - Near elimination of GF wear (+demonstrated fuel savings)
  - Increase of AOA with increase in TOR wear

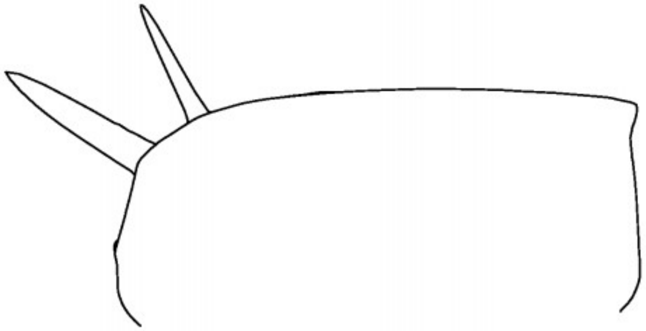




Graphics taken from [1]

System Impact

- Reduced GF wear but increased shelling at GC
  - 30% increase in emergency rail replacement
- Rail profile optimized for specific wear conditions
  - Rail would quickly wear in to a 2-point conformal contact
  - GF lubrication: no wear and high stress 2-point contact



Photos: [2]

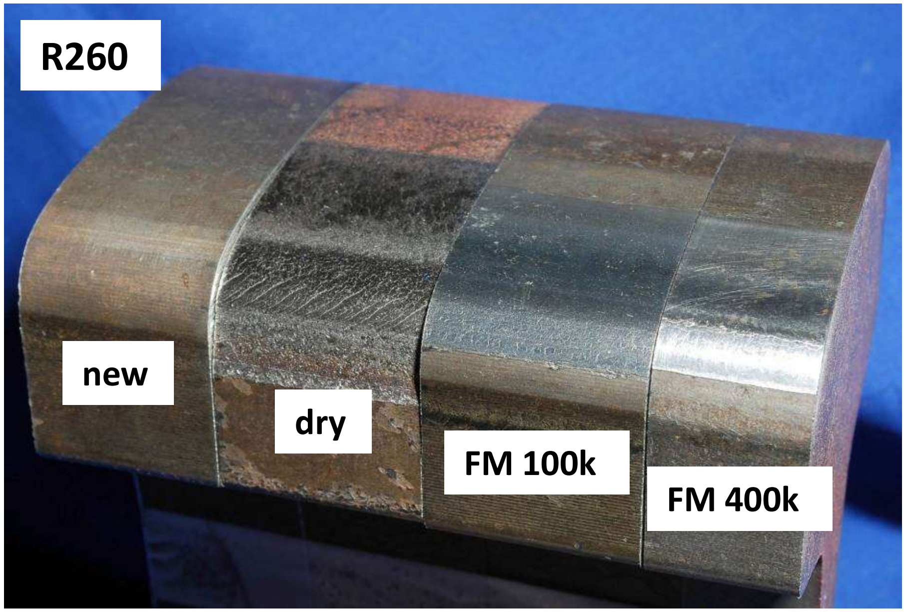
System Solution

- New rail profiles to reduce stresses in mild and sharp curves
  - Good steering, less stress, 2-pt conformal contact
- Adapted grinding strategies to remove damage / create profile
  - Grinding to 60° angle
  - Preventive gradual strategy

Photos: [2]

Friction Management

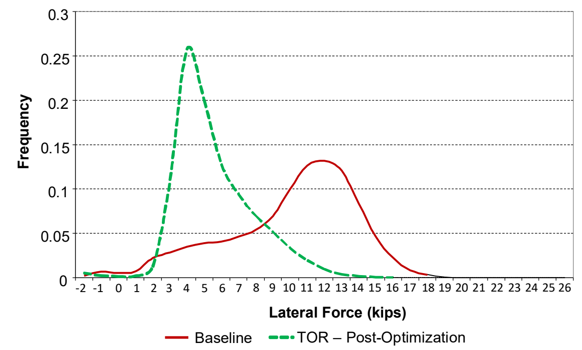
- GF lubrication only – high AOA and TOR wear, RCF
- TOR friction control – reduce friction to intermediate level
- TFM: combined application of GF + TOR

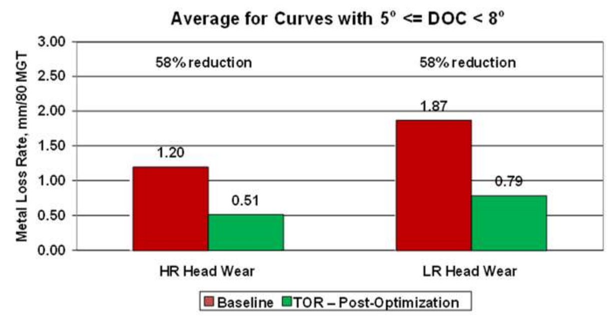


Source: L.B. Foster

Effects of Friction Management

- NRC "100% Effective Friction Management" Project (2004-2005) [3], [4], [5]
- Measurement with L/V sites
  - Lateral forces reduced by 24% - 40%
- No GF wear
- Vertical wear (L/H) reduced by 50%





Track Geometry

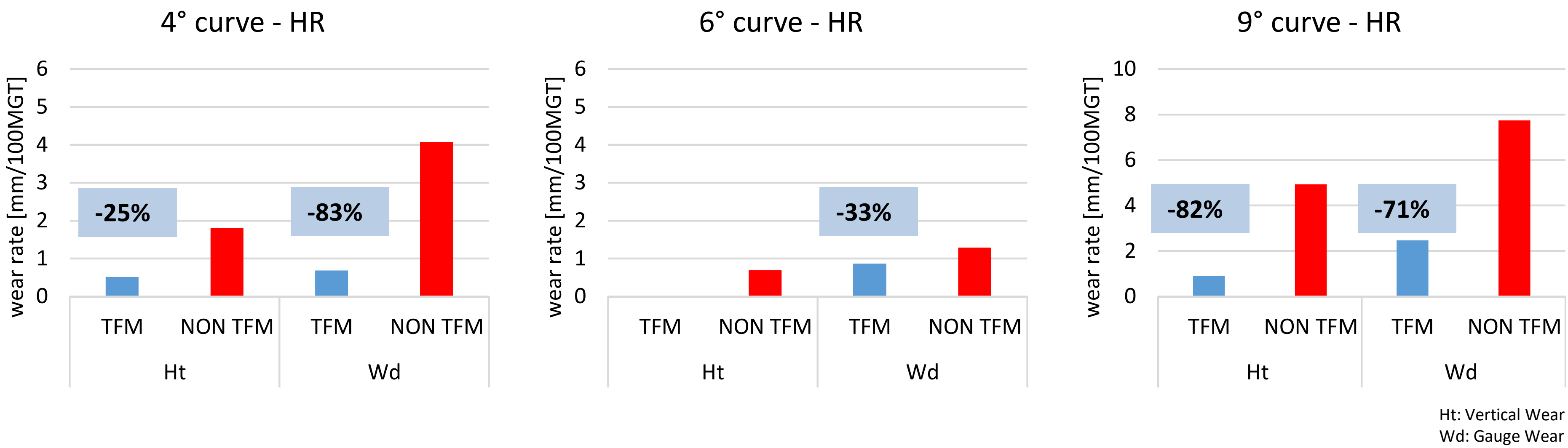
- Advanced analysis of required superelevation (SE) bandwidth
  - Uphill vs. downhill
  - Train type and within a train
- Track adjustments cannot solve the problem
- Optimised distributed power + FM to narrow the SE bandwidth
  - Adjust SE in specific corridors

Photo: CP [5]

TFM: 10 years later

- Re-evaluation of FM results in 2017 [6]
  - LB Foster, CP
- Analysis of three subdivision with and without FM
- Curves: 4°, 6° and 9° curve
- Data source: Geometry Car and Rail Grinder

Natural Wear – High Rail

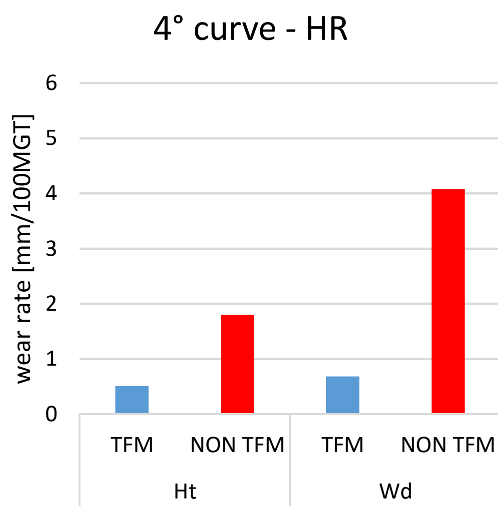


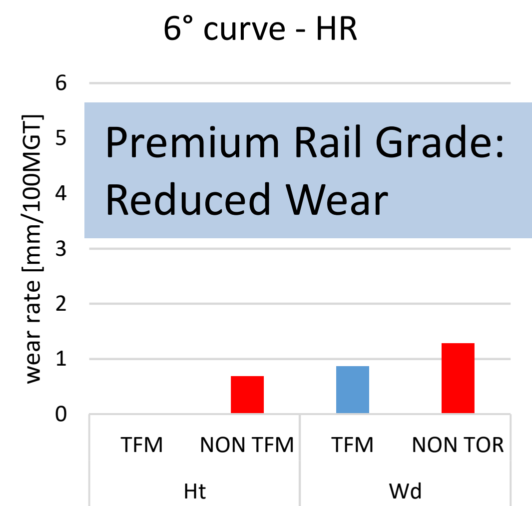
- High rail: GF and TOR wear reduced

Source of graphics: [6]

Rail Grade Influence

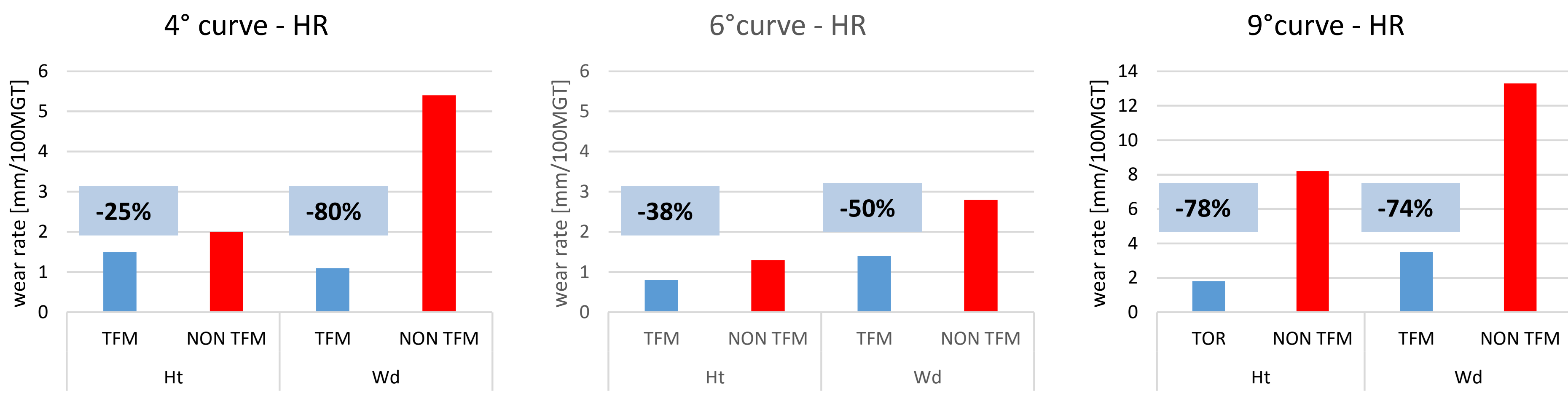
- Intermediate Grade (4° curve) vs. Premium Rail Grade(6° curve)





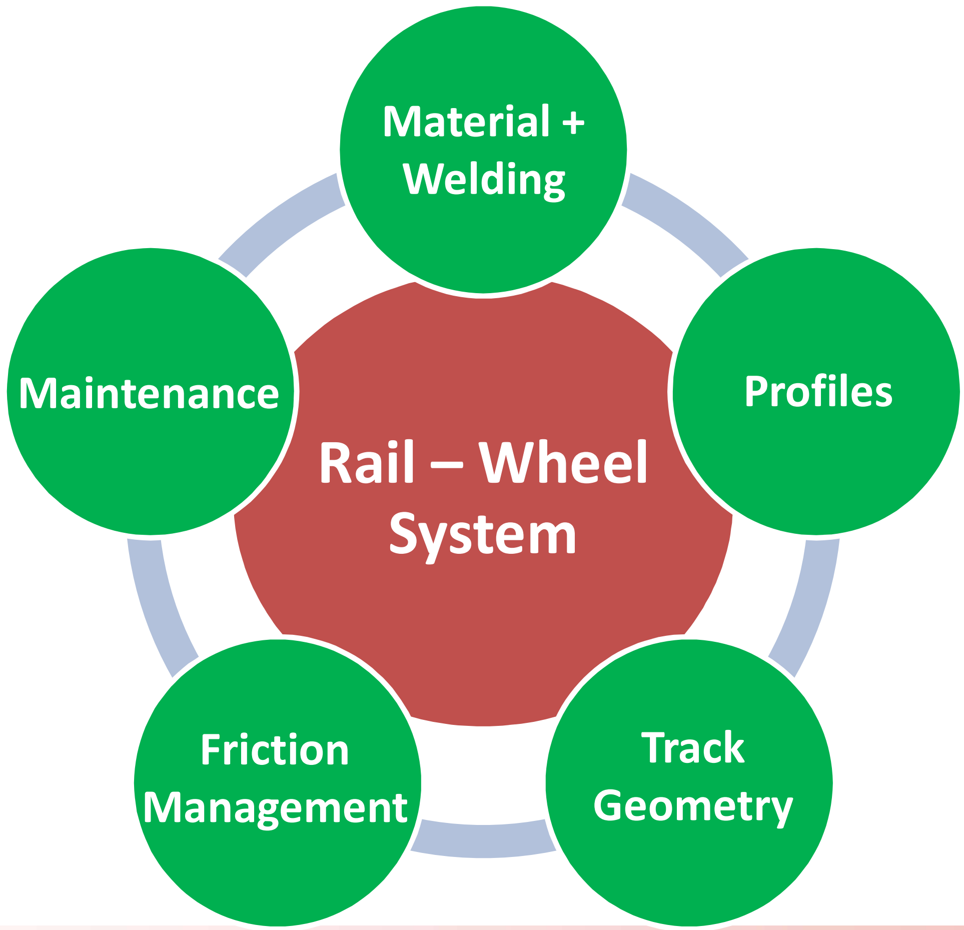
Source of graphics: [6]

Impact on Grinding



- Less metal removal in TFM curves

Source of graphics: [6]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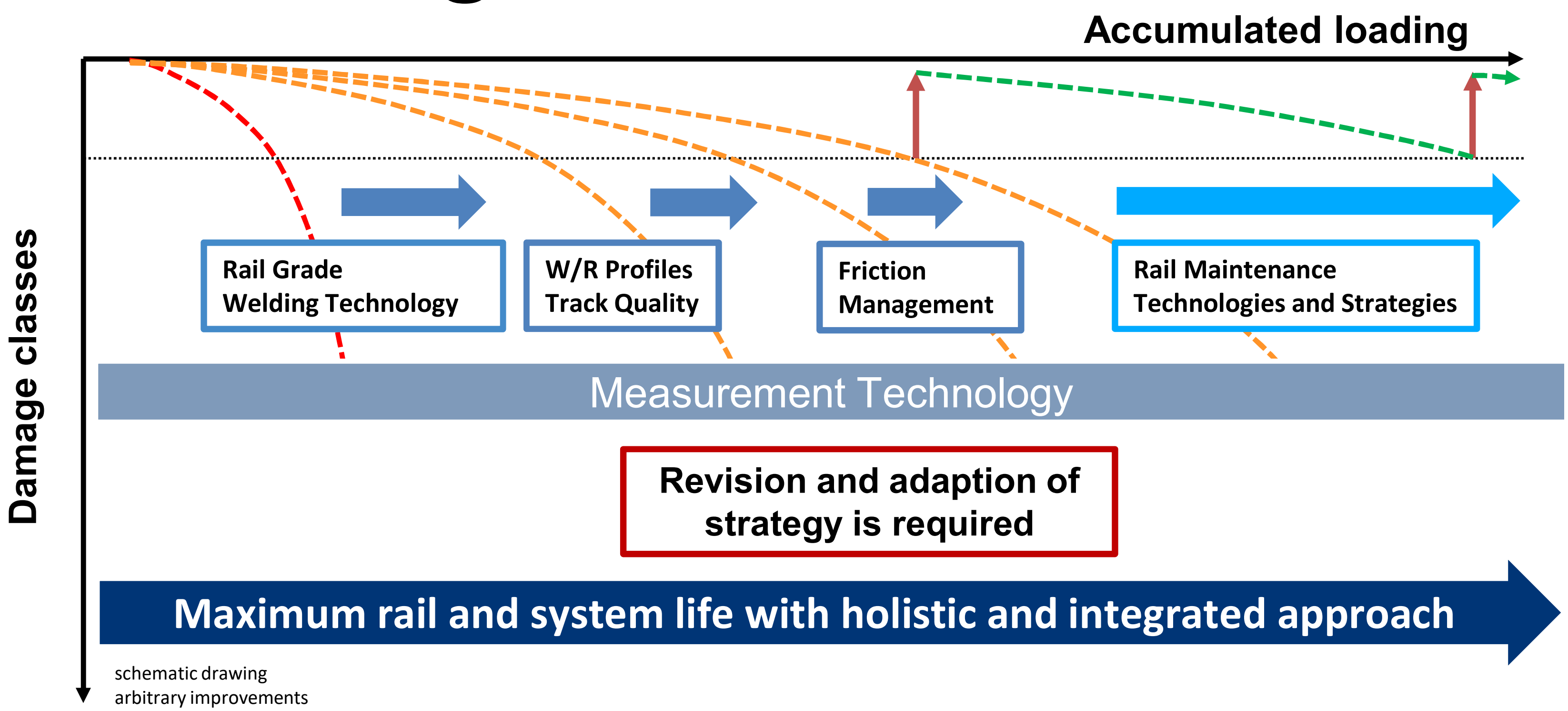

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