Quantifying Rail Life Extension with Infinite Pattern Control

Chris Lidberg

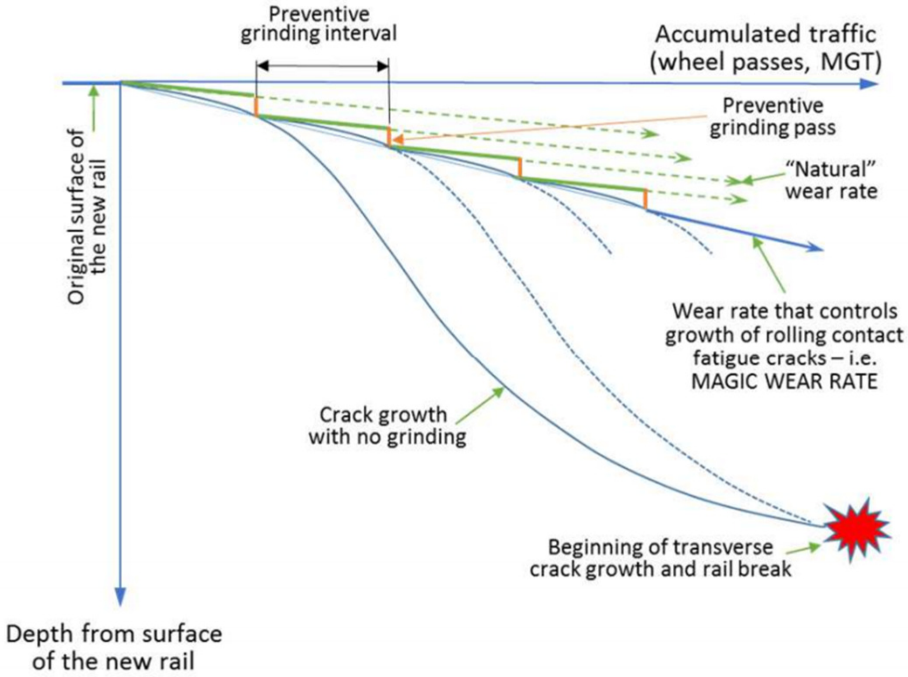
Product Manager

Loram, Maintenance of Way

Why Grind

Rail grinding leads to an extension of rail life by

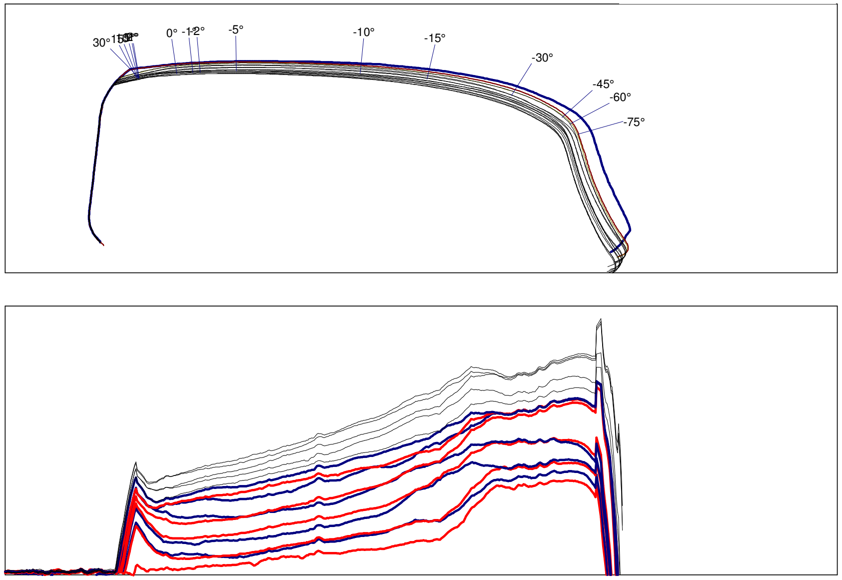
- Removing rolling contact fatigue (RCF) on the surface of the rail
- Maintaining the optimal rail profile



E. Magel, J. Kalousek, P. Sroba, "Chasing the Magic Wear Rate", in J. Pombo, (Editor), "Proceedings of the Second International Conference on Railway Technology: Research, Development and Maintenance", Civil-Com p Press, Stirlingshire, UK, Paper 116, 2014. doi: 10.4203/ ccp.104.116

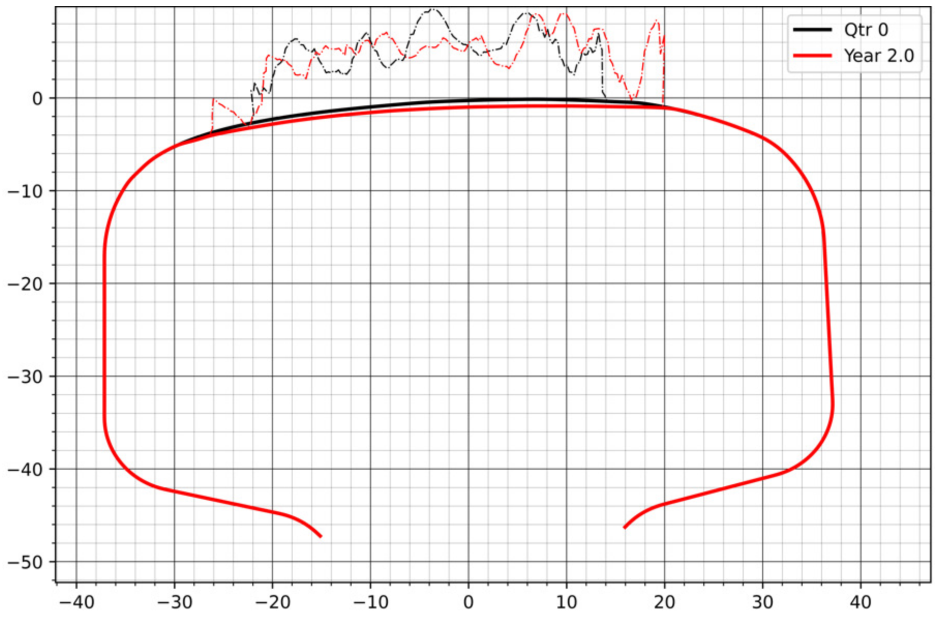
Optimized Rail Profile (AREMA Best Practices)

Rail wear due to tonnage causes rail-surface plastic flow and surface fatigue (spalling, shelling, and head checks) and increases the internal stresses in the rail that initiate rail defects



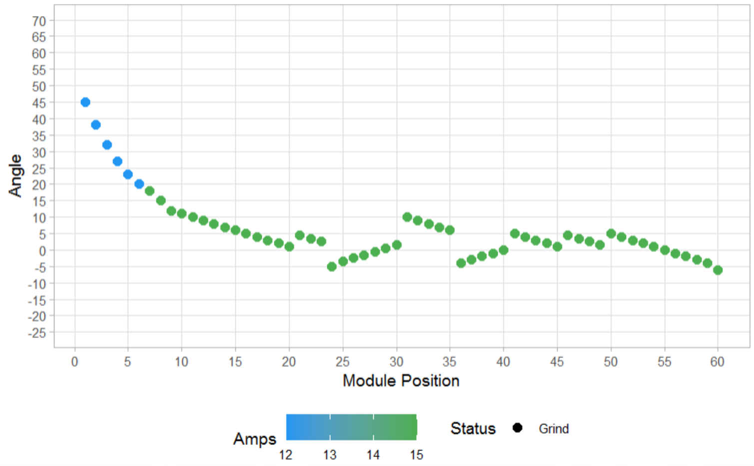
Optimized Rail Profile (AREMA Best Practices)

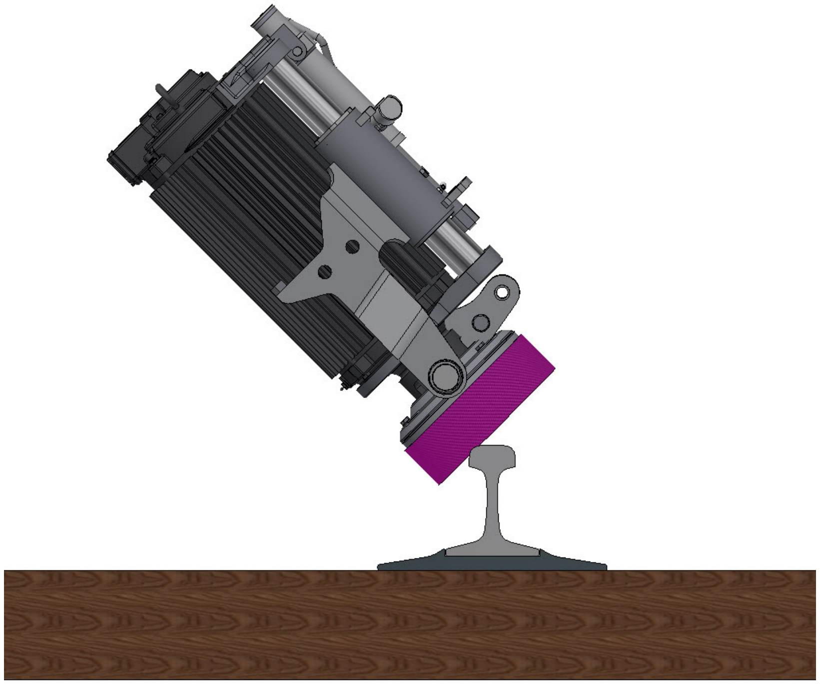
Maintaining designed transverse rail profiles (templates) optimized over expected wheel profiles through rail grinding leads to reduced contact stress, improved vehicle stability in tangent track, and improved wheelset curving

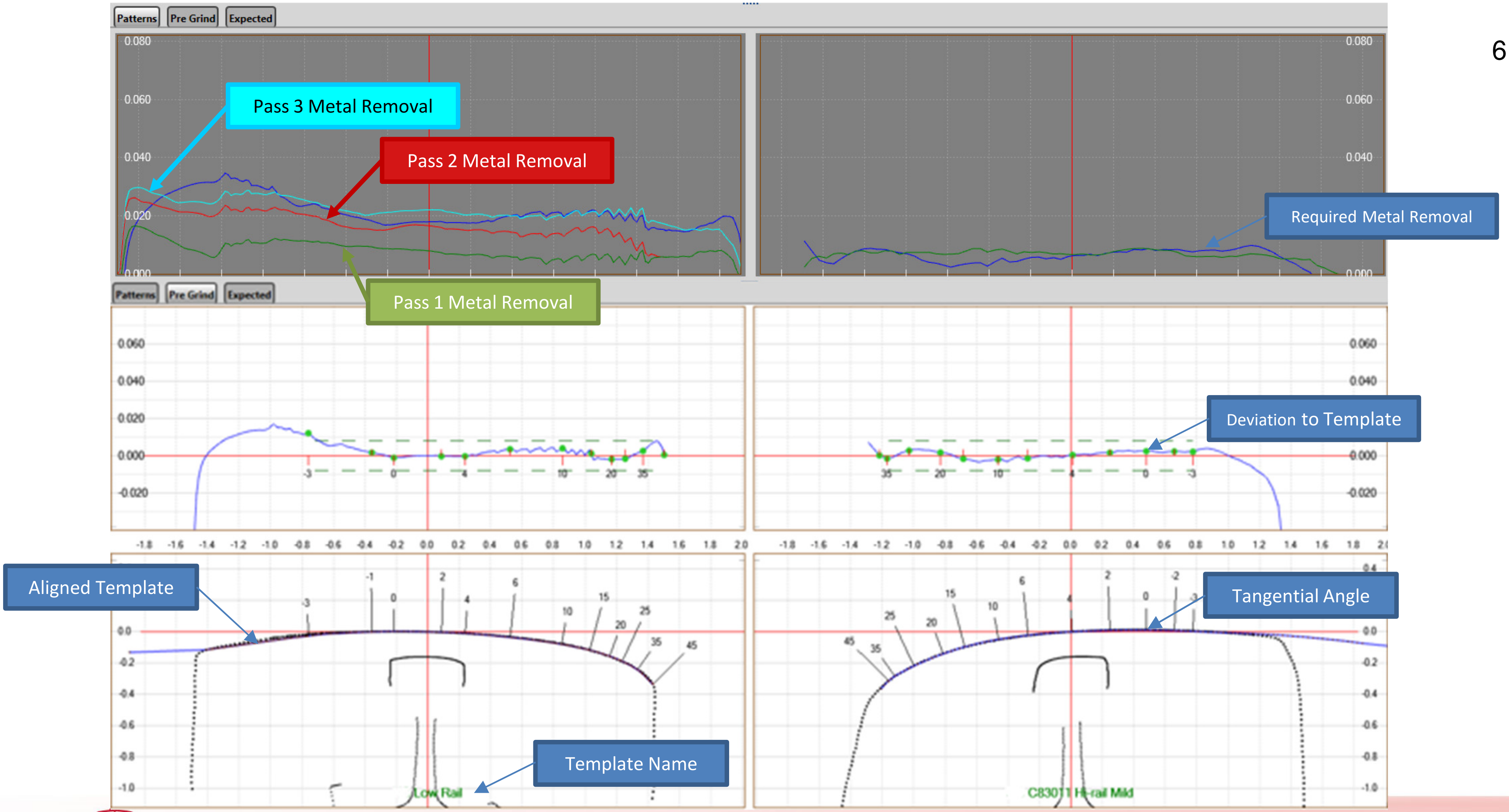


Grind Patterns

A grind pattern is a distribution of grind modules at specific angles and amps throughout a rail grinder used to grind to a template







Pass 3 Metal Removal

Pass 2 Metal Removal

Pass 1 Metal Removal

Required Metal Removal

Deviation to Template

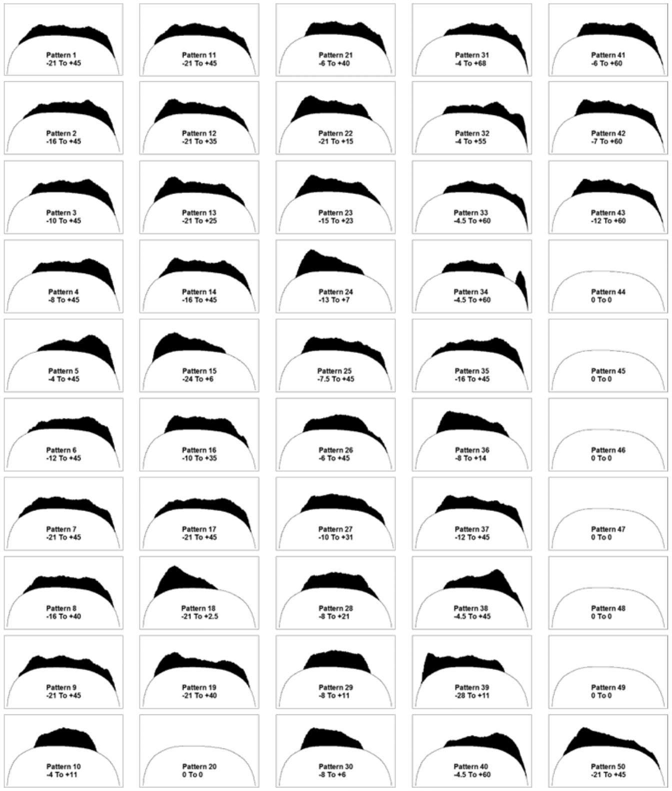
Aligned Template

Tangential Angle

Template Name

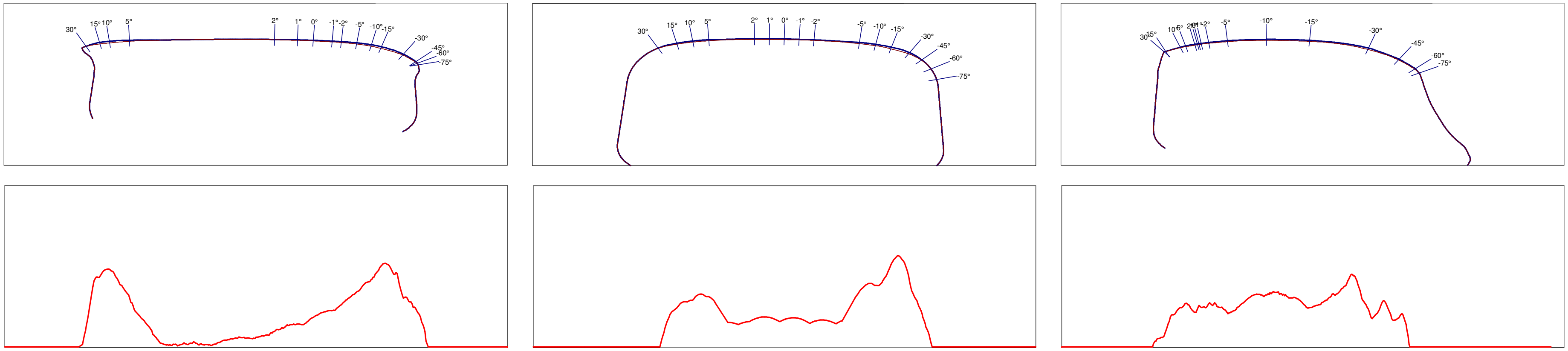
Pattern Selection (Static)

- Up to 50 patterns
- Grind speeds called at 1 mph increments
- Patterns chosen to “fit” required metal removal
- <u>Ensure minimum</u> depth of cut is achieved



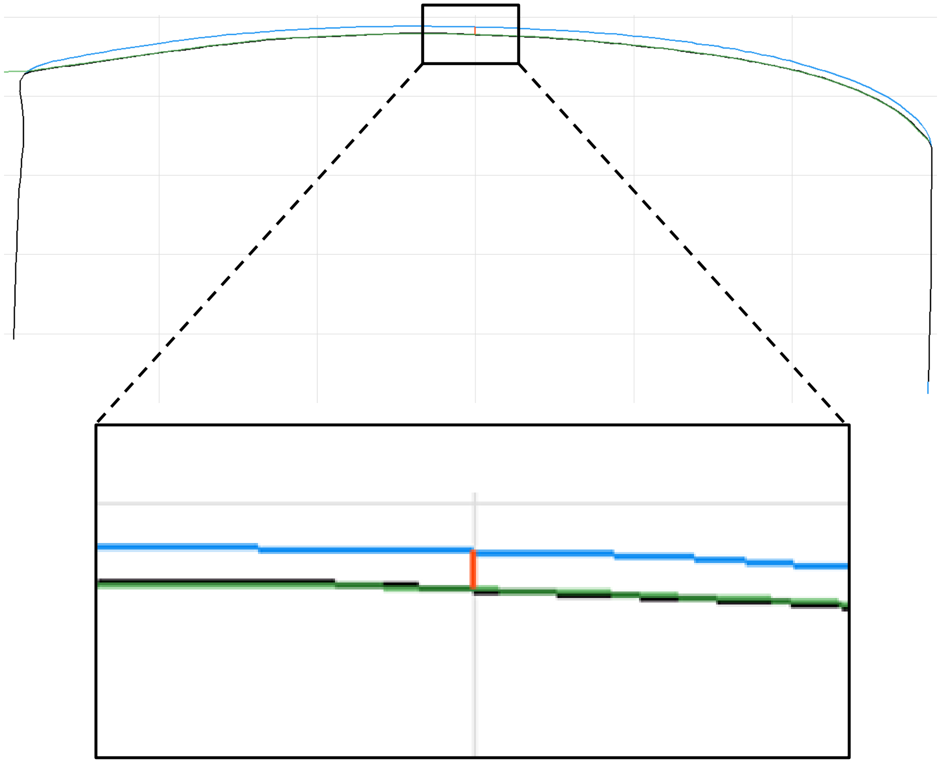
Pattern-Rail Interaction

- A pattern does not give consistent metal removal depending on the rail shape
- The same pattern can yield completely different metal removal for a flat, low rail compared to a gauge-worn high rail

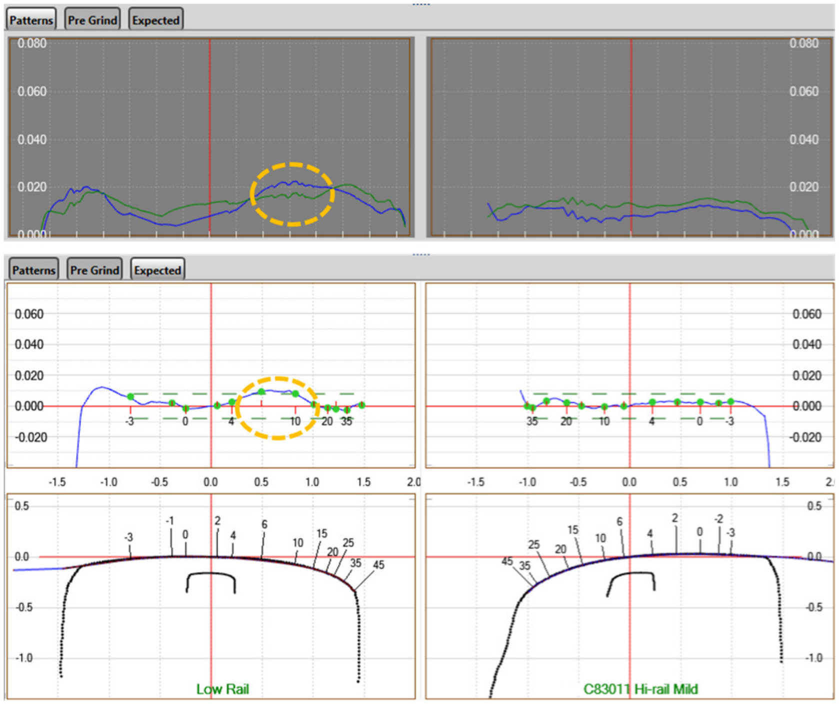


Pattern Creation (Dynamic)

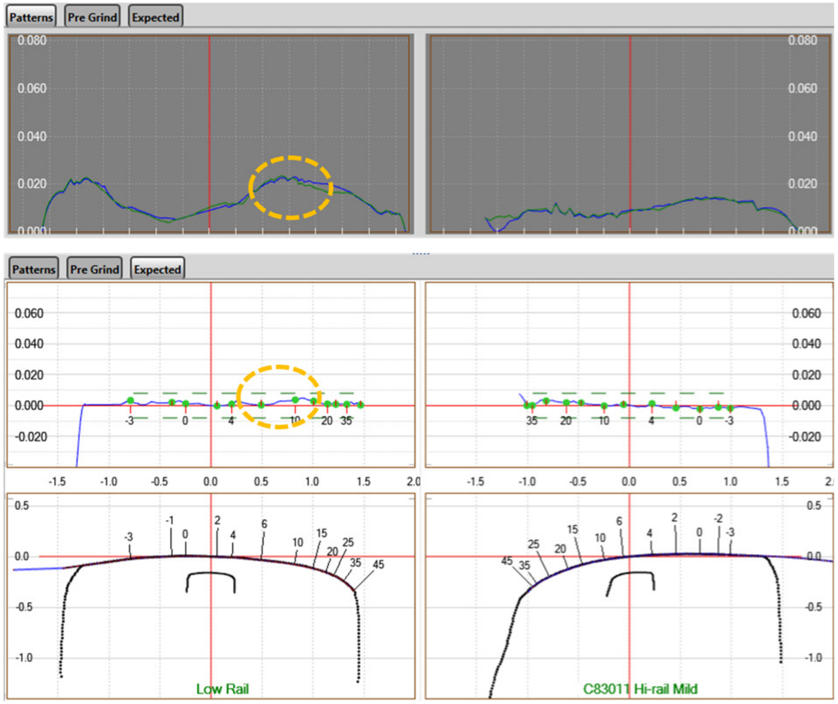
- Practically infinite number of patterns
- Grind speeds called at 0.1 mph increments
- Patterns systematically created to match desired finish rail profile
- Targets <u>exact</u> required depth of cut



Exact Match to the Template

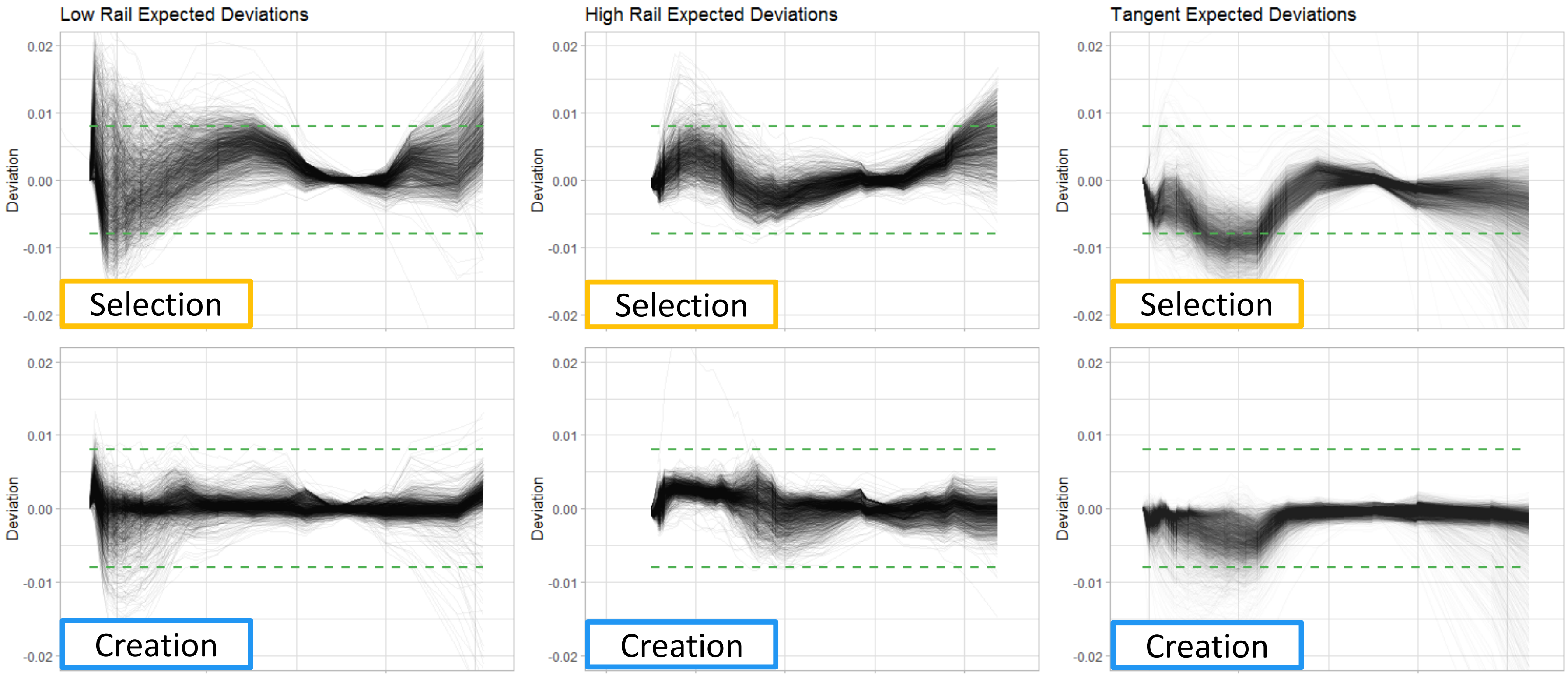


Pattern Selection

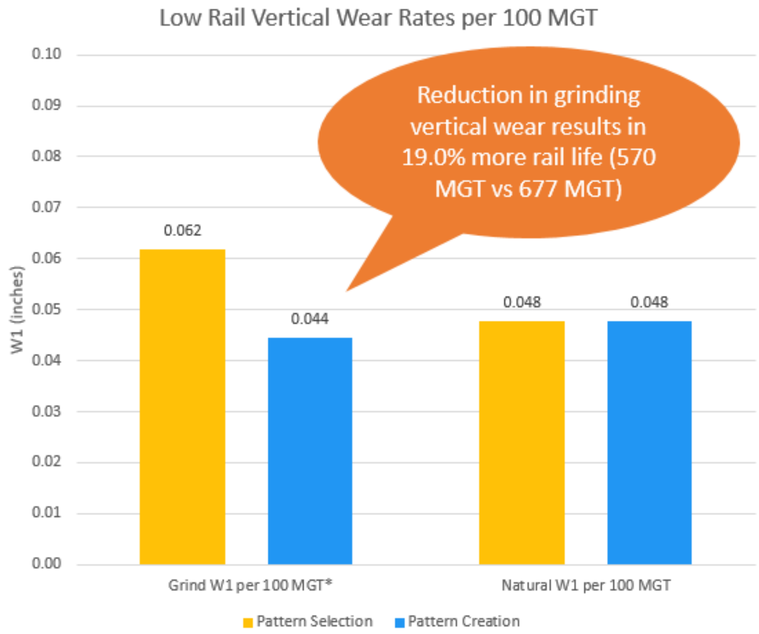


Pattern Creation

Expected Deviations from Template

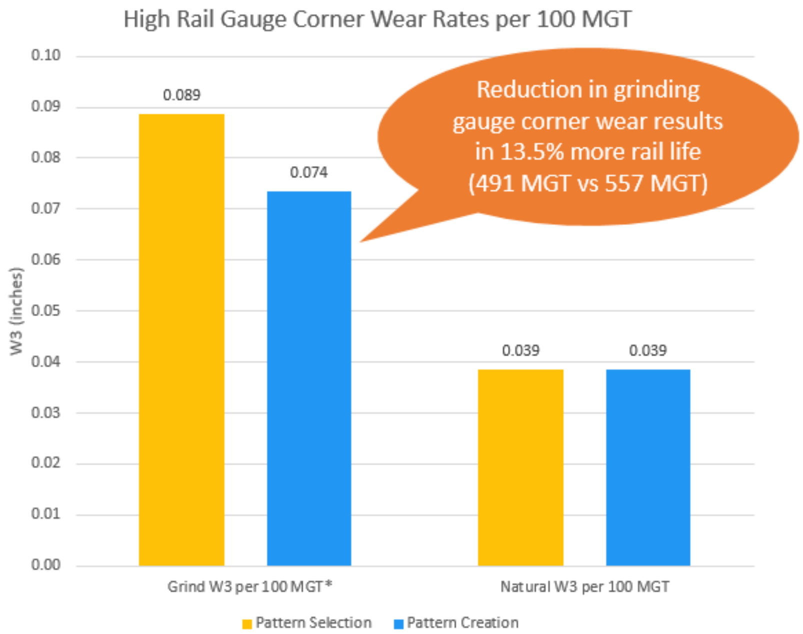


Rail Life Increase



Low Rail Vertical Wear Rates per 100 MGT

Reduction in grinding vertical wear results in 19.0% more rail life (570 MGT vs 677 MGT)



High Rail Gauge Corner Wear Rates per 100 MGT

Reduction in grinding gauge corner wear results in 13.5% more rail life (491 MGT vs 557 MGT)

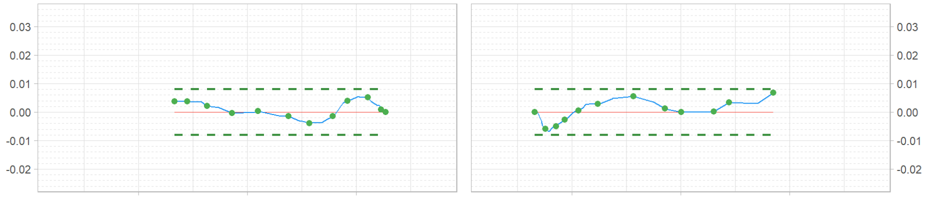
*Grind wear estimated based on expected metal removal on same inspections using pattern creation and pattern selection

** Results presented at WRI in 2021

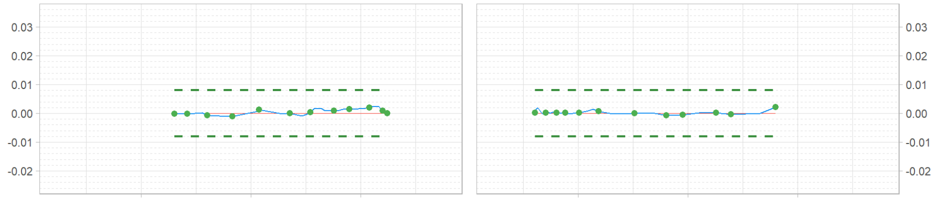
Modeling Natural Wear

- Using a digital twin, can we compare expected natural wear rates of the most representative pattern selection cases to the pattern creation cases?
- What is the evolution of wear rates during a normal cycle? What if the cycle is extended beyond a typical 30-40 MGT (million gross tons)?
- How do the natural wear rates effect rail life in each case?

Expected Template Deviation – Pattern Selection

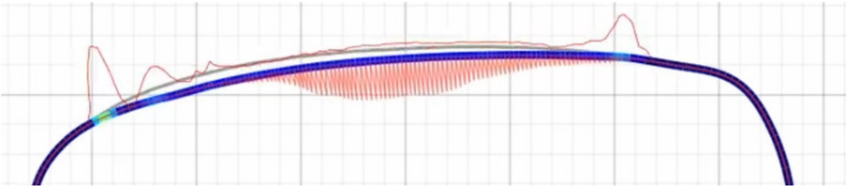


Expected Template Deviation – Pattern Creation

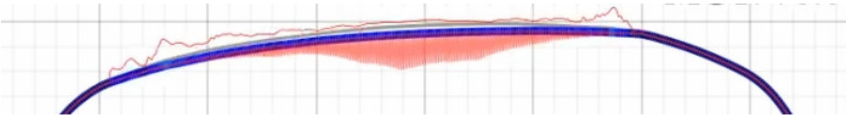


Natural Wear Modeling

- Traffic patterns, wheel and rail profiles, friction conditions, and metallurgy are used to forecast natural wear with accumulated tonnage postgrind
- Rail profiles are split between two cases to determine the expected natural wear between pattern creation and pattern selection
  (1) The most representative profiles on the high and low rails of curves found during the pattern selection time period
  (2) The same curves from (1) with the expected output of pattern creation

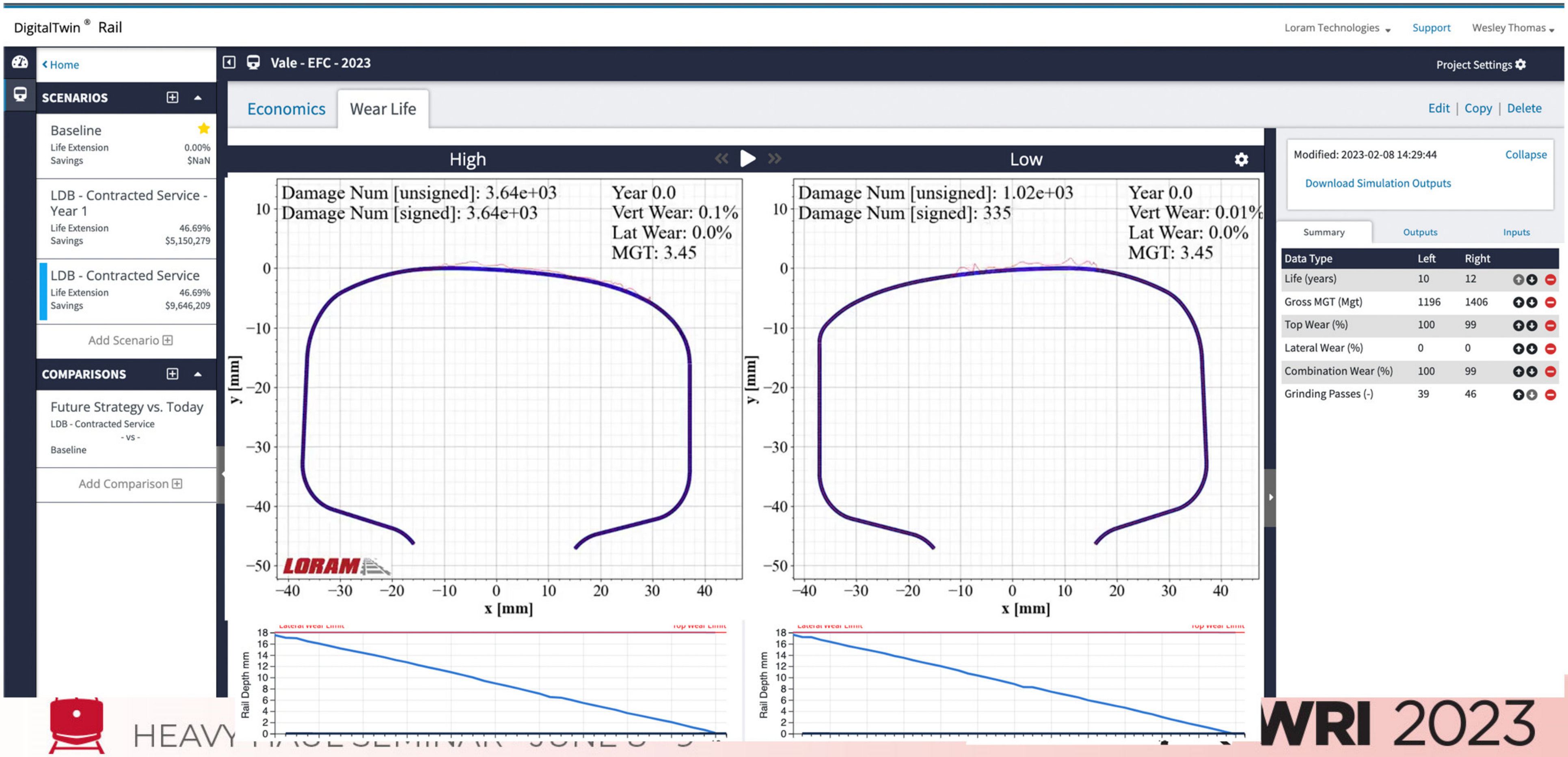


Pattern Selection Case



Pattern Creation Case

Full Wear Simulation



DigitalTwin ® Rail

Loram Technologies | Support | Wesley Thomas

‹ Home

Vale - EFC - 2023

Project Settings

SCENARIOS

Baseline
Life Extension 0.00%
Savings $NaN

LDB - Contracted Service - Year 1
Life Extension 46.69%
Savings $5,150,279

LDB - Contracted Service
Life Extension 46.69%
Savings $9,646,209

Add Scenario

COMPARISONS

Future Strategy vs. Today
LDB - Contracted Service
- vs -
Baseline

Add Comparison

Economics | Wear Life

Edit | Copy | Delete

Modified: 2023-02-08 14:29:44

Collapse

Download Simulation Outputs

Summary | Outputs | Inputs

Data Type	Left	Right
Life (years)	10	12
Gross MGT (Mgt)	1196	1406
Top Wear (%)	100	99
Lateral Wear (%)	0	0
Combination Wear (%)	100	99
Grinding Passes (-)	39	46

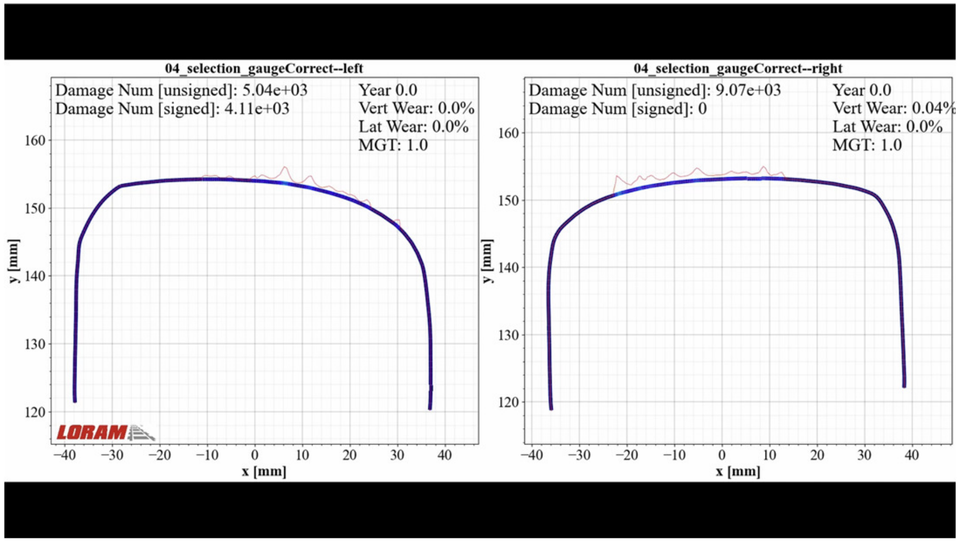
Wear Modeling Results

	Selection						Creation					
	High Rail			Low Rail			High Rail			Low Rail		
Case	Top Wear [inch]	Lateral Wear [inch]	Gauge Wear [inch]	Top Wear [inch]	Lateral Wear [inch]	Gauge Wear [inch]	Top Wear [inch]	Lateral Wear [inch]	Gauge Wear [inch]	Top Wear [inch]	Lateral Wear [inch]	Gauge Wear [inch]
1	0.002	0.000	0.004	0.011	0.000	0.001	0.002	0.000	0.006	0.013	0.000	0.000
2	0.006	0.003	0.010	0.014	0.000	0.001	0.004	0.000	0.009	0.015	0.000	0.000
3	0.002	0.001	0.006	0.012	0.000	0.002	0.002	0.000	0.007	0.015	0.000	0.000
4	0.001	0.000	0.005	0.013	0.000	0.001	0.002	0.000	0.007	0.015	0.000	0.000
5	0.001	0.000	0.004	0.012	0.000	0.001	0.002	0.000	0.006	0.015	0.000	0.000
6	0.003	0.076	0.050	0.013	0.000	0.001	0.005	0.000	0.010	0.015	0.000	0.000
7	0.001	0.022	0.016	0.012	0.000	0.002	0.002	0.000	0.007	0.015	0.000	0.000
8	0.000	0.024	0.014	0.009	0.000	0.001	0.002	0.000	0.003	0.012	0.000	0.000
9	0.004	0.028	0.020	0.014	0.000	0.000	0.004	0.000	0.009	0.015	0.000	0.000
10	0.001	0.012	0.011	0.011	0.000	0.002	0.002	0.000	0.006	0.014	0.000	0.000

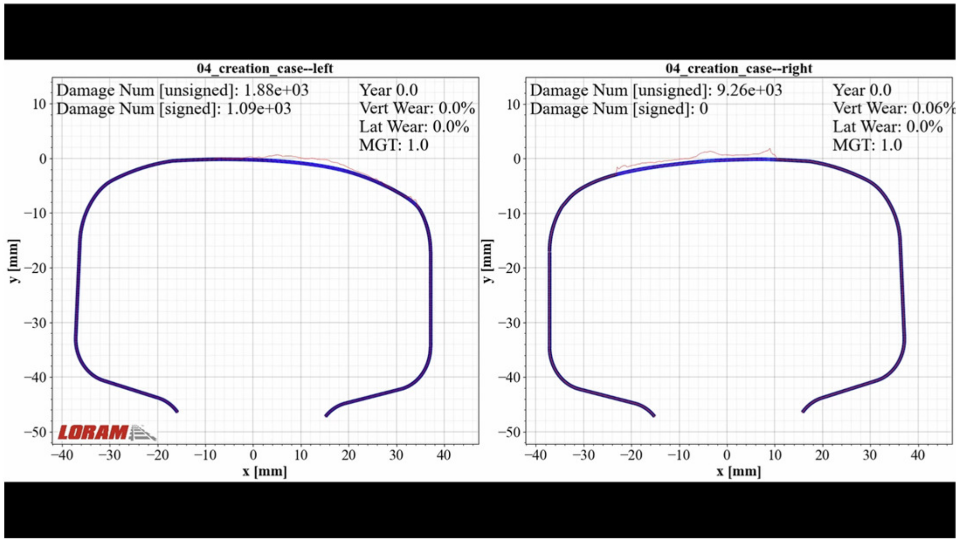
* Wear modeling results are 40 MGT postgrind

Wear Simulation – Mild Curve (Case 4)

Selection

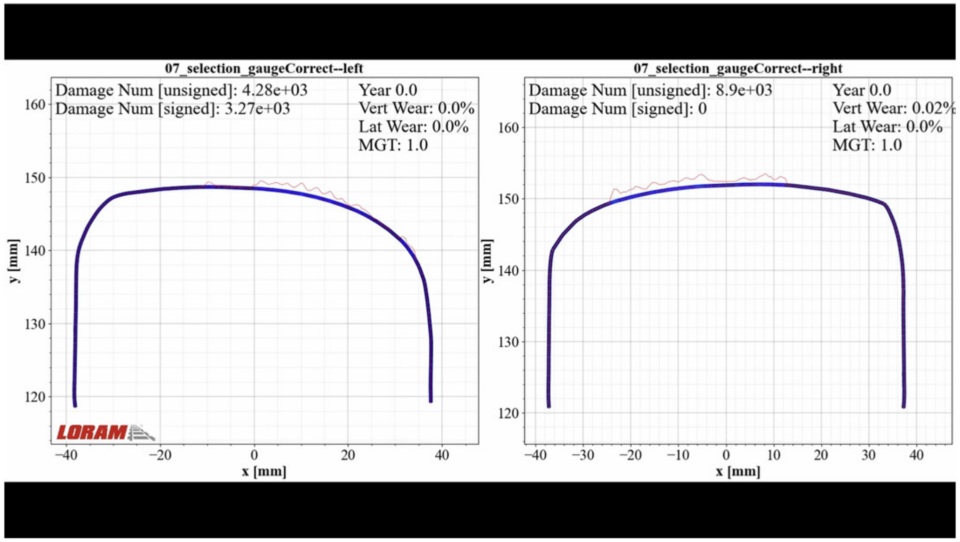


Creation

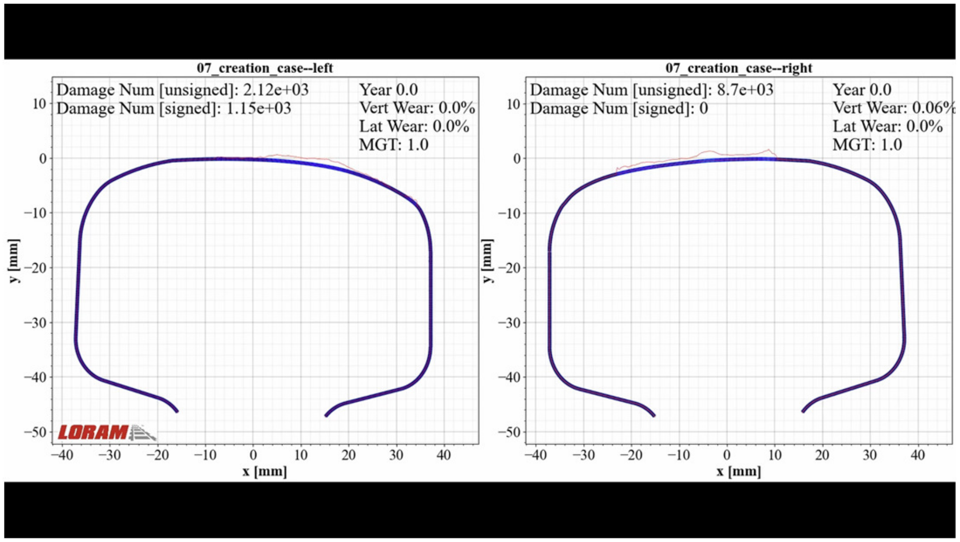


Wear Simulation – Medium Curve (Case 7)

Selection

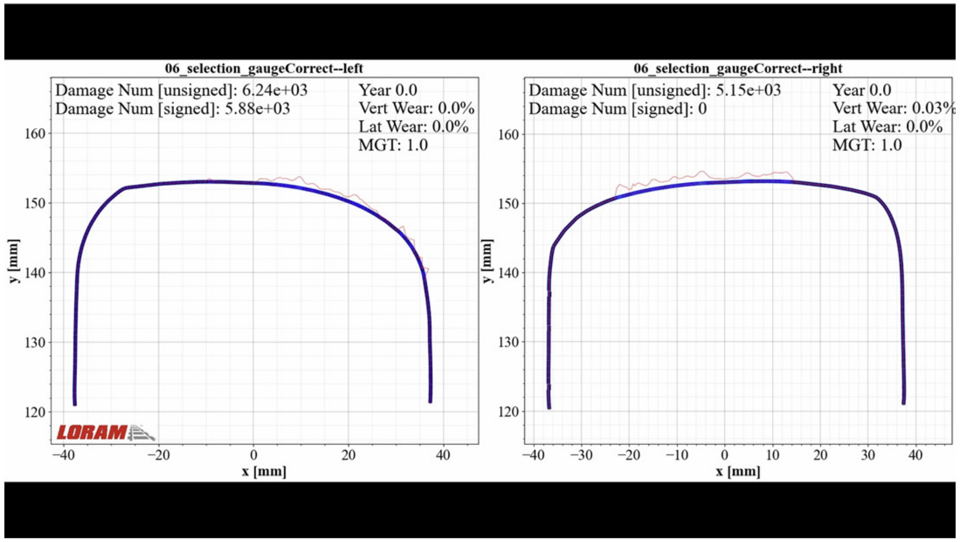


Creation

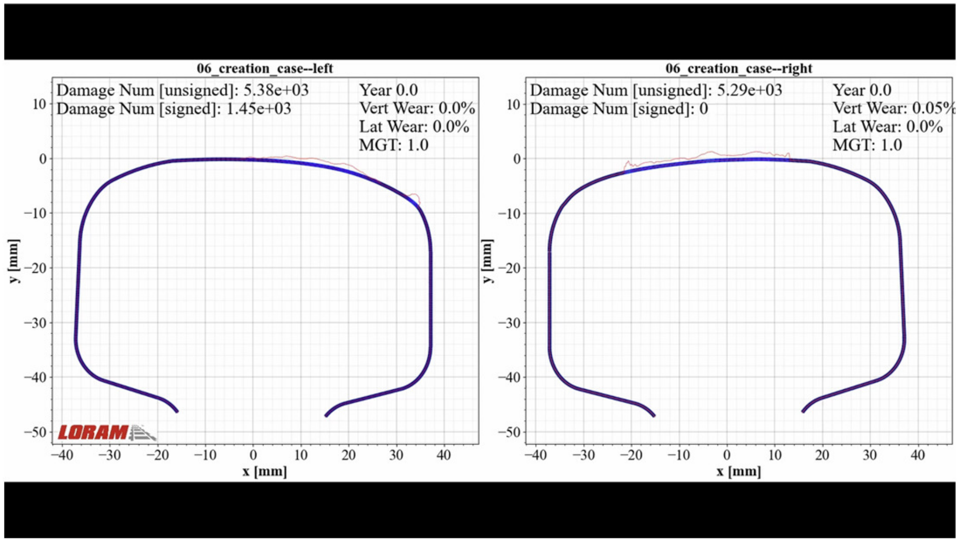


Wear Simulation – Sharp Curve (Case 6)

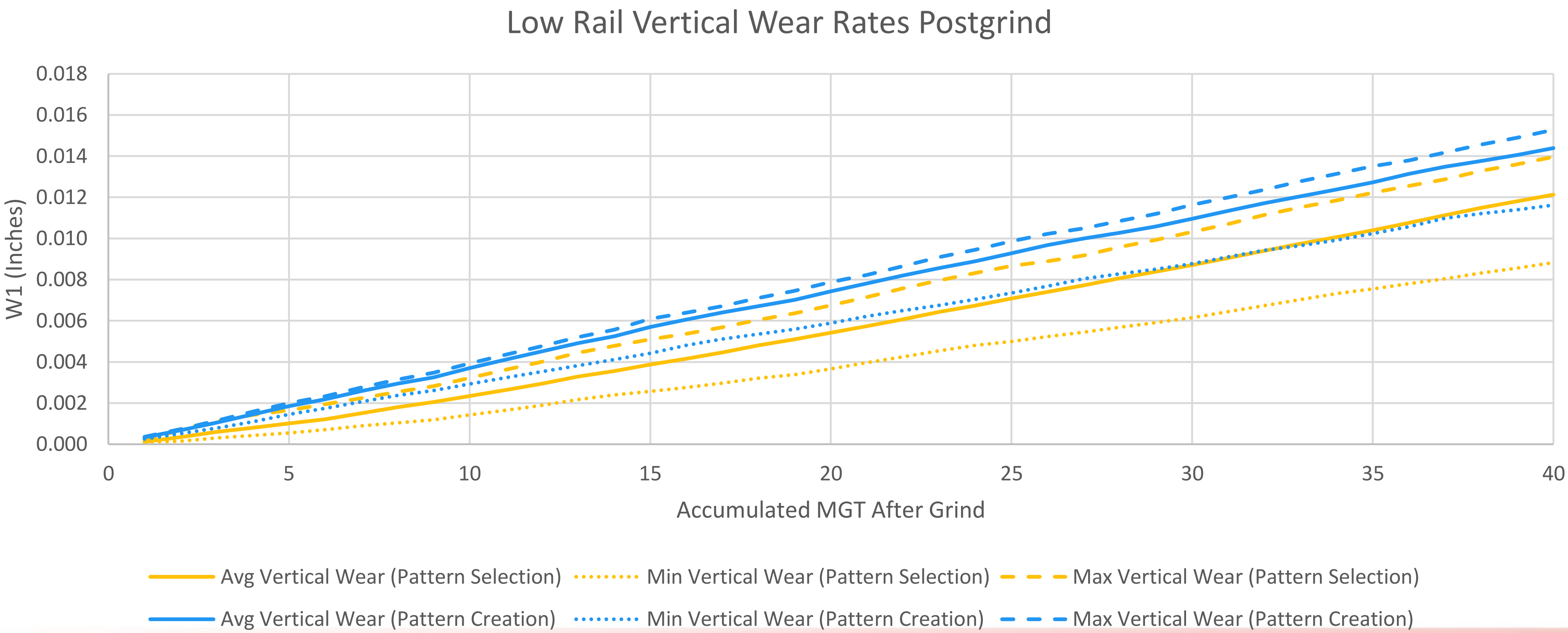
Selection



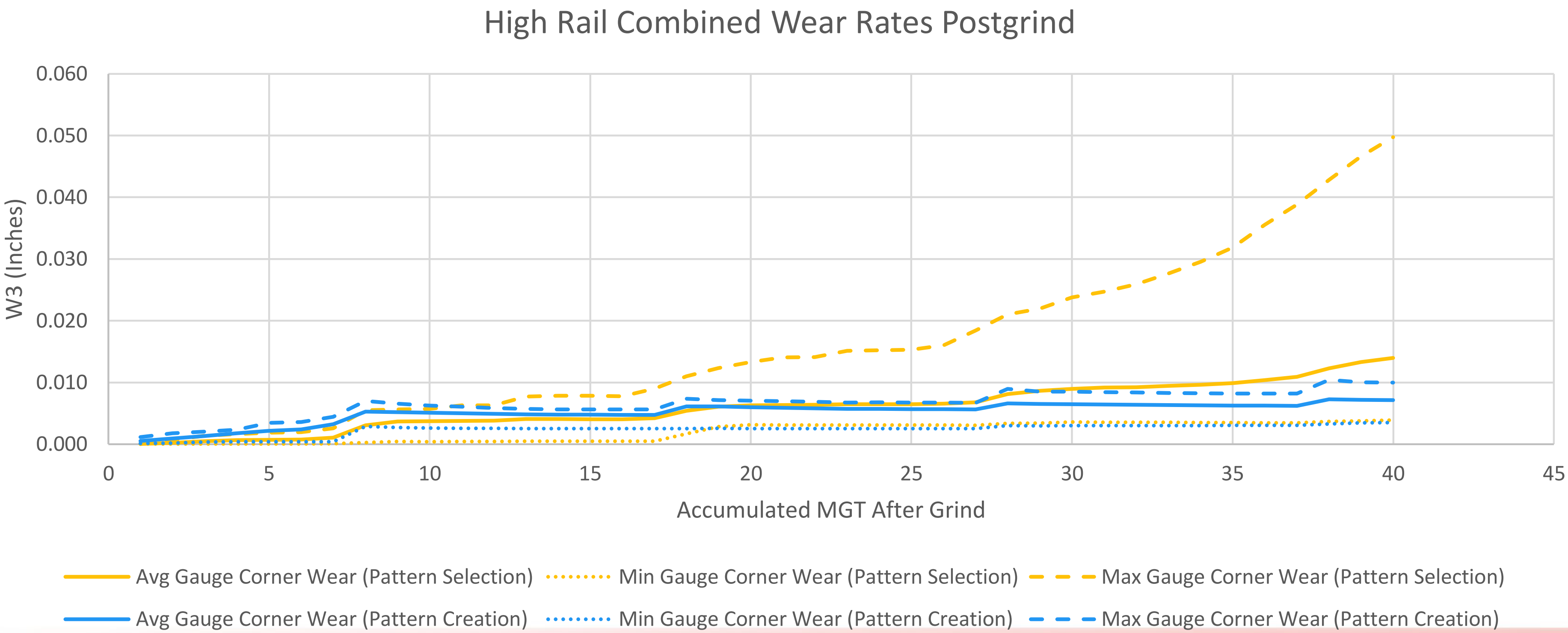
Creation



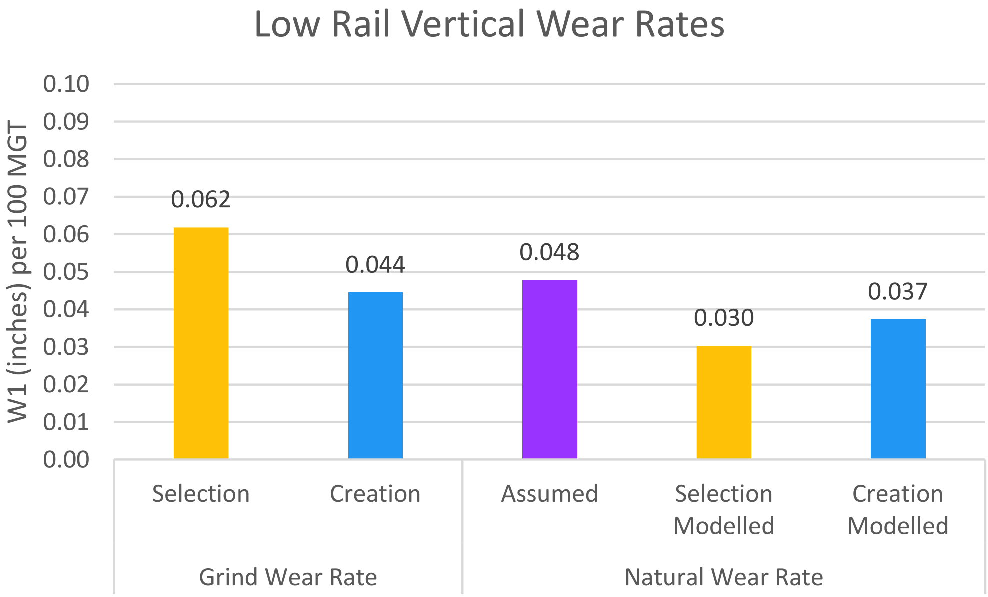
Wear Rates Postgrind

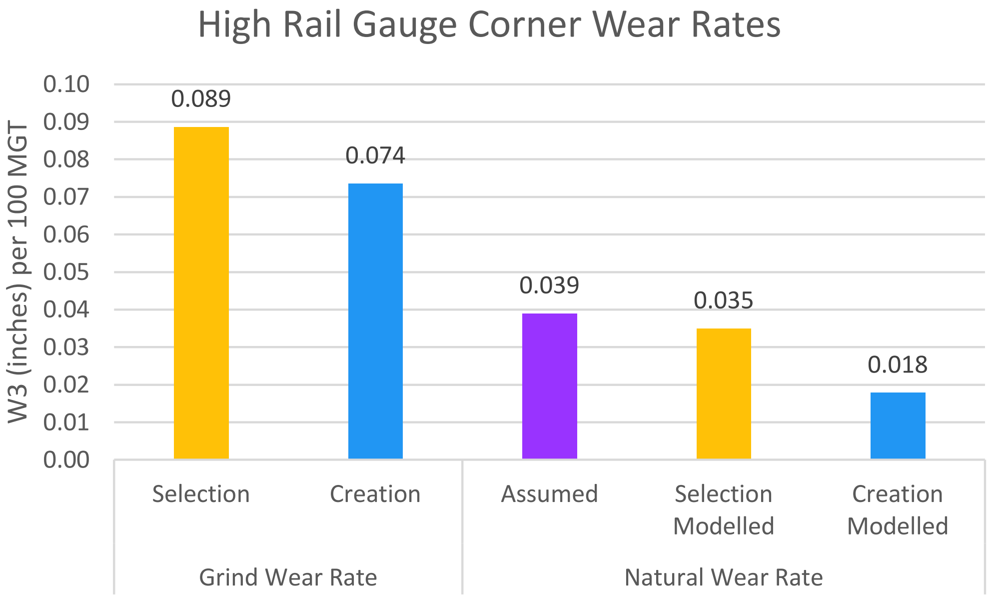


Wear Rates Postgrind



Updates in Natural Wear





Low Rail Expected Life (MGT)			
Wear Rate	Selection	Creation	% Change
Assumed Natural Wear	570	677	19%
Modelled Natural Wear	678	764	13%

High Rail Expected Life (MGT)			
Wear Rate	Selection	Creation	% Change
Assumed Natural Wear	489	555	13%
Modelled Natural Wear	505	683	35%

Conclusions

- Modeling natural wear based on most expected traffic and wheel conditions show that initial natural wear estimates were higher than expected
- Wear rates in the simulated profile have an uneven balance in life between low and high rails
- Even with higher natural wear rates on low rails, due to lower grind efforts on vertical wear location, rail is expected to last longer
- Results continue to show that pattern creation is an effective tool to extend the life of the rail. With optimal profile design, extension of rail life could be higher than we are realizing today.

Thank you!

Special thanks to the Norfolk Southern and Brandon Sherrod for their cooperation in field testing over the past four years.

Also wanted to thank my colleagues at LTI who were instrumental in analysis presented.

Chris Lidberg, M.S., PMP
Product Manager
christopher.j.lidberg@loram.com
+1 612 219 2285