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IMPROVING THE UTILIZATION OF BOGIE PERFORMANCE DETECTORS

Naples, 22nd November 2016

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Evolution of Wayside

1940-50's – First "wayside" systems – basic hot box and dragging-equipment detectors

1960-80's – Radio transmission of hotbox and dragging-equipment results

– Early testing of RFID tagging solutions, and then creation of AEI standard

1990's – More complex wayside condition monitoring systems enter the market

– Bogie Performance Detectors for Geometry/Stability (TBOGI), Wheel Profile Systems, Acoustic Bearing Detectors, and Wheel Impact Load Detectors

2000's – Move from basic "go / no go" to more centralized data and trending tools

– Wayside "supersites" start becoming cohesive with more shared infrastructure

2010's – Improving data analysis and composite thresholds

– Extending the functionality of wayside systems

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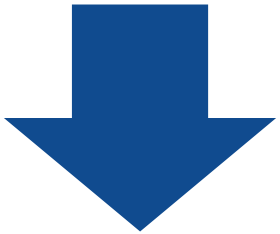
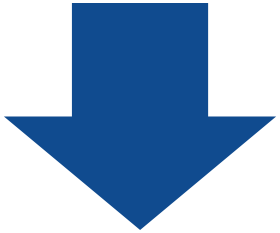
Why?

What is happening at the Wheel-Rail Interface



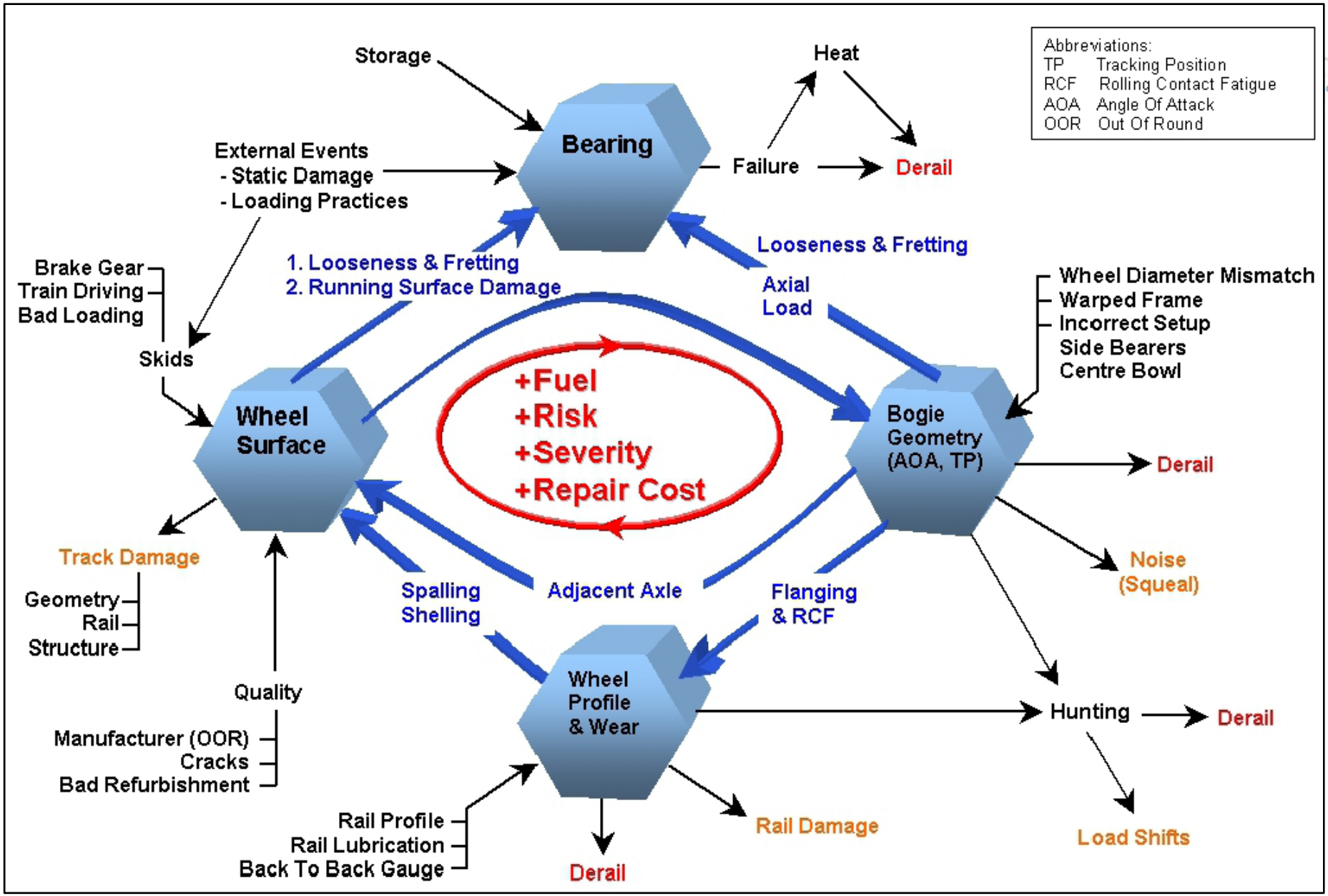
Reveal Causality

Identify where money is being lost



Targeted Action

Achieve the goals of wayside monitoring



Excerpt from Bladon, K., Rennison, D., Izbinsky, G., Tracy, R. and Bladon, T., 2004, Predictive Condition Monitoring of Railway Rolling Stock. In: CORE 2004: New Horizons for Rail. Darwin, N.T.: Railway Technical Society of Australasia (RTSA), 22.1-22.12.

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How were early Bogie Performance Detectors used to evaluate bogies, and what were the challenges?

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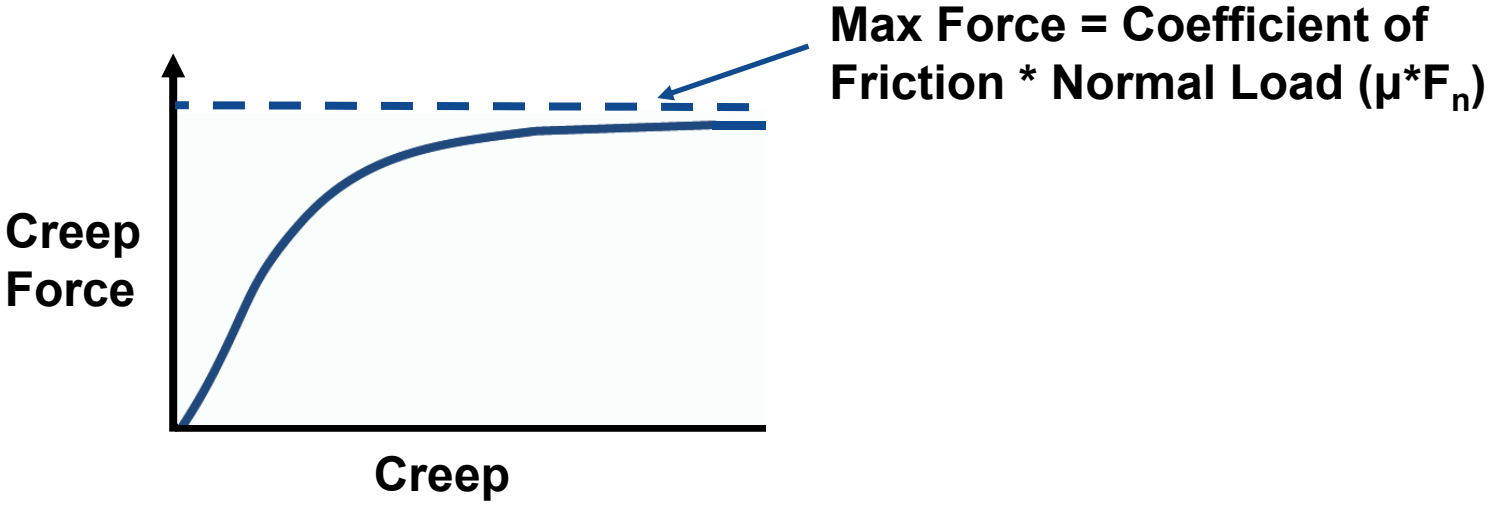
Early BPMs

Forces on tangent and curve are variable depending on speed, wagon length, load, direction, and friction coefficient.

Strain gauges can sense vertical and lateral forces, but only a very limited view of longitudinal or spin forces.

Creep and Creep Force are not directly related: low forces could be very good or very bad.



Graph adapted from: Dembosky M. 2015 "Wheel Rail Principles: Driving Factors, Results and Experience". The 1st Annual Wheel Rail Interaction Conference - EU, Derby, October 2015

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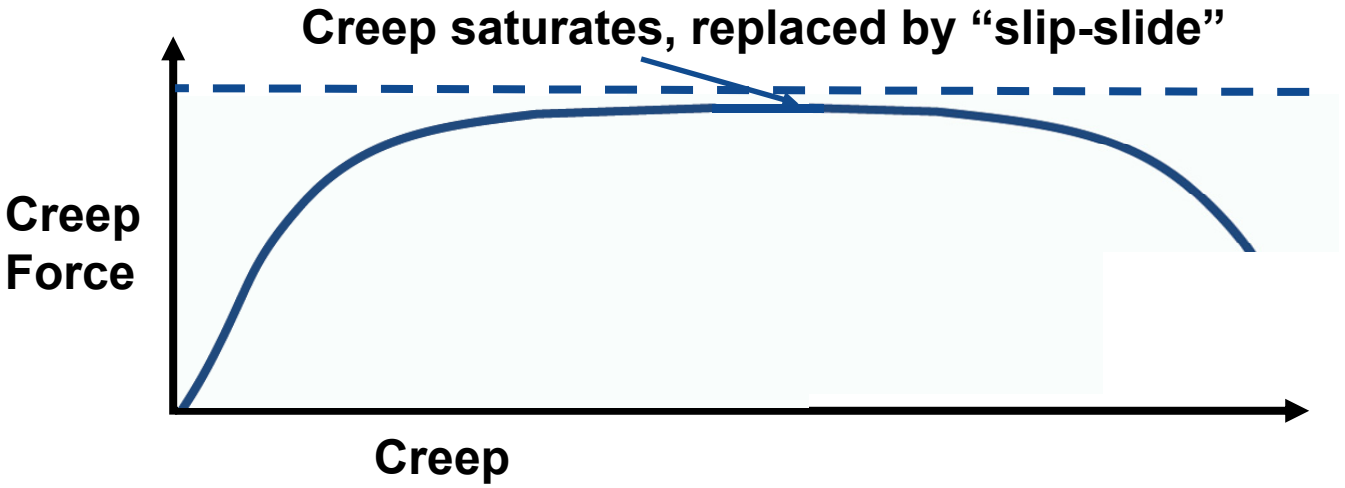

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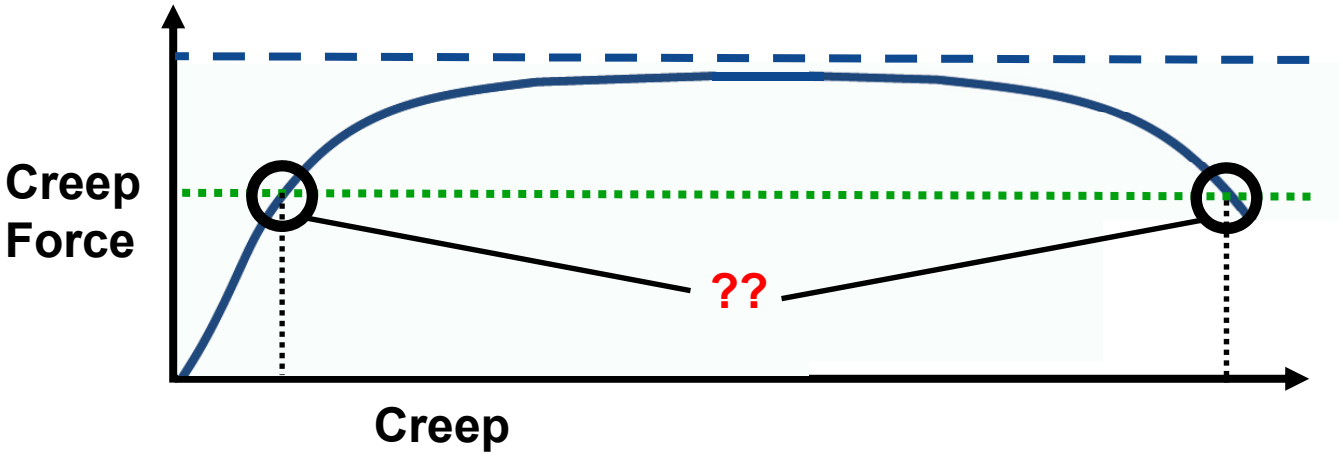

Graph adapted from: Dembosky M. 2015 "Wheel Rail Principles: Driving Factors, Results and Experience". The 1st Annual Wheel Rail Interaction Conference - EU, Derby, October 2015

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How do modern BPDs evaluate the wheel-rail interface itself, and what have been the experiences in improving the utilisation of this information?

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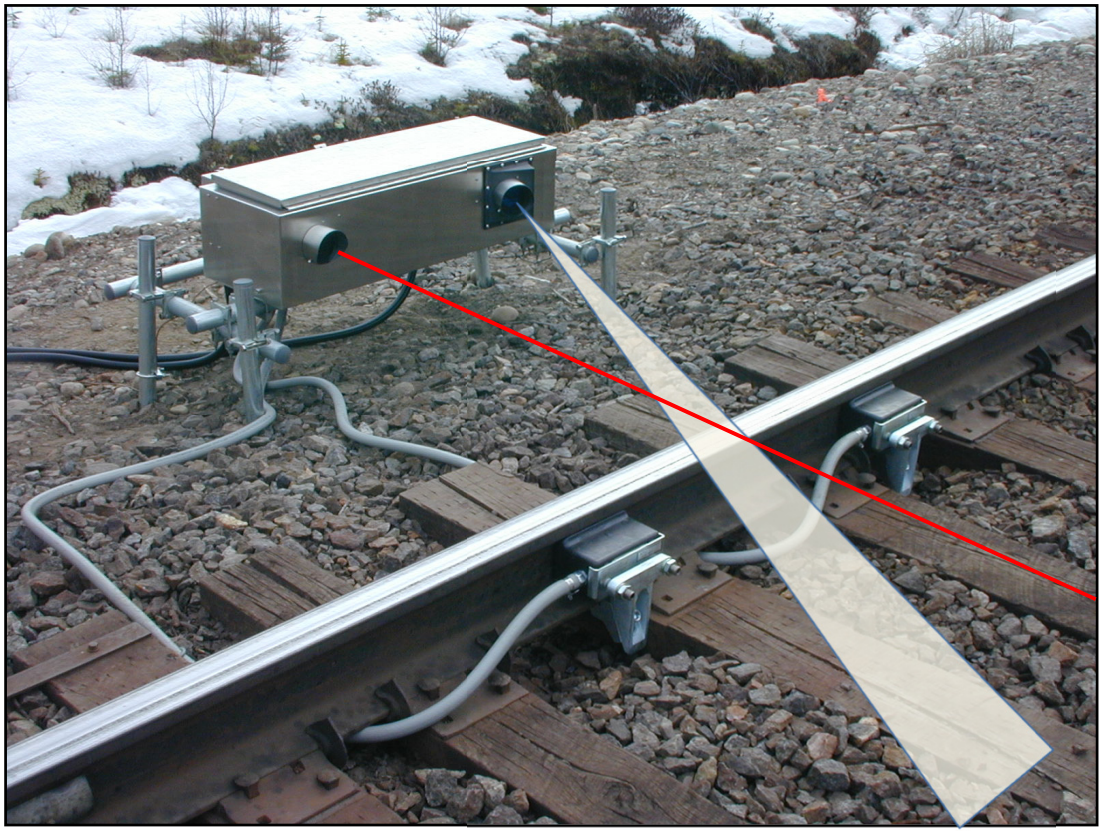
The TBOGI System

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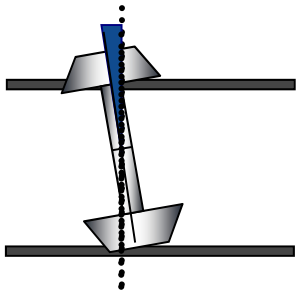
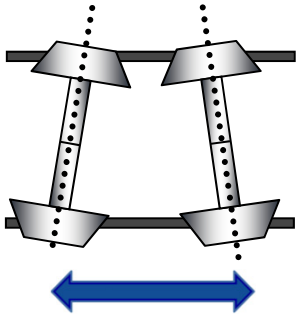
Effects of Defective Tracking Behaviour
Angle-of-Attack



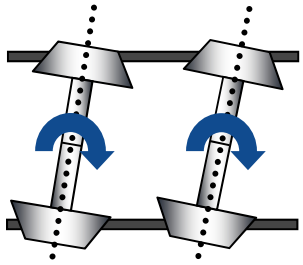
Above Rail

- Material flows on the wheel
- <u>Hollow wheel wear</u>
- Specific root causes for each type of AoA defect – wheelset vs bogie



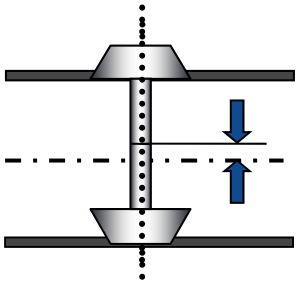
Below Rail

- Intermittent crown wear as lateral material flows, particularly in curves
- Deformation discontinuities form as corrugations or material flow
- Lateral fatigue cracking and that can lead to rail breaks



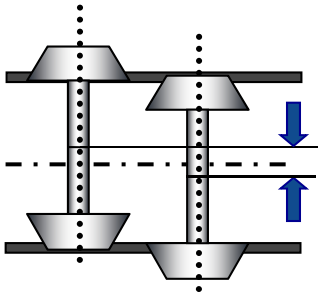
Effects of Defective Tracking Behaviour

Tracking Position



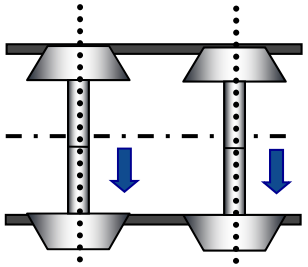
Above Rail

- Material flows on the wheel
- Flange wheel wear
- Specific root causes for each type of TP defect – wheelset vs bogie

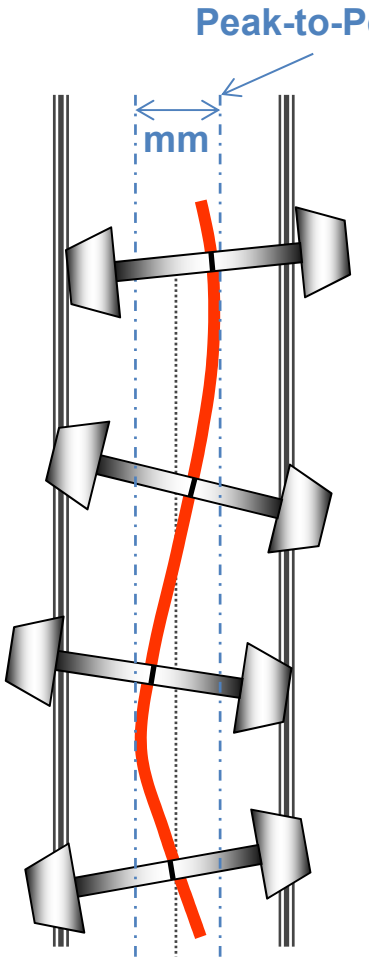


Below Rail

- Head checking / gauge corner cracking
- Shelling
- Longitudinal fatigue cracking
- Flow of flash-butt material on the gauge corner of the rail



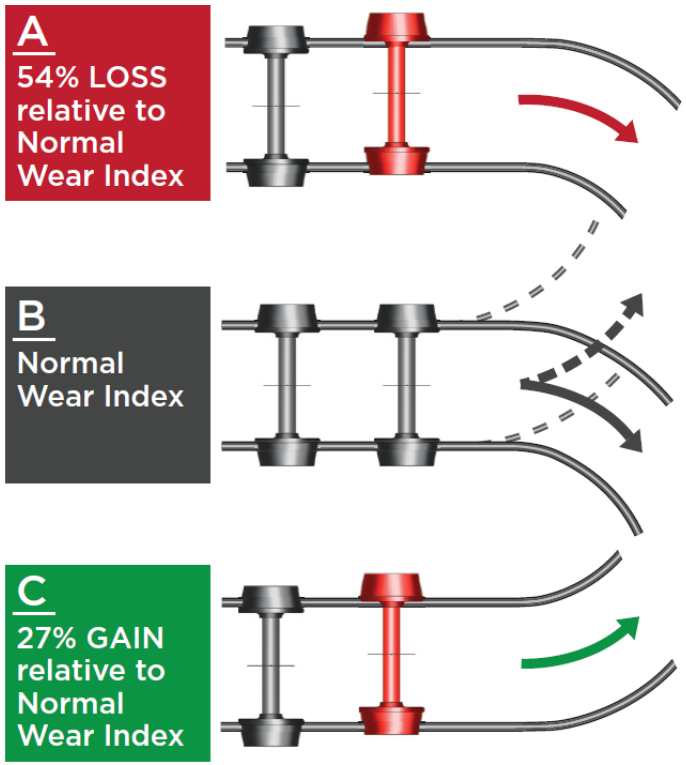
Effects of Defective Tracking Behaviour
Hunting

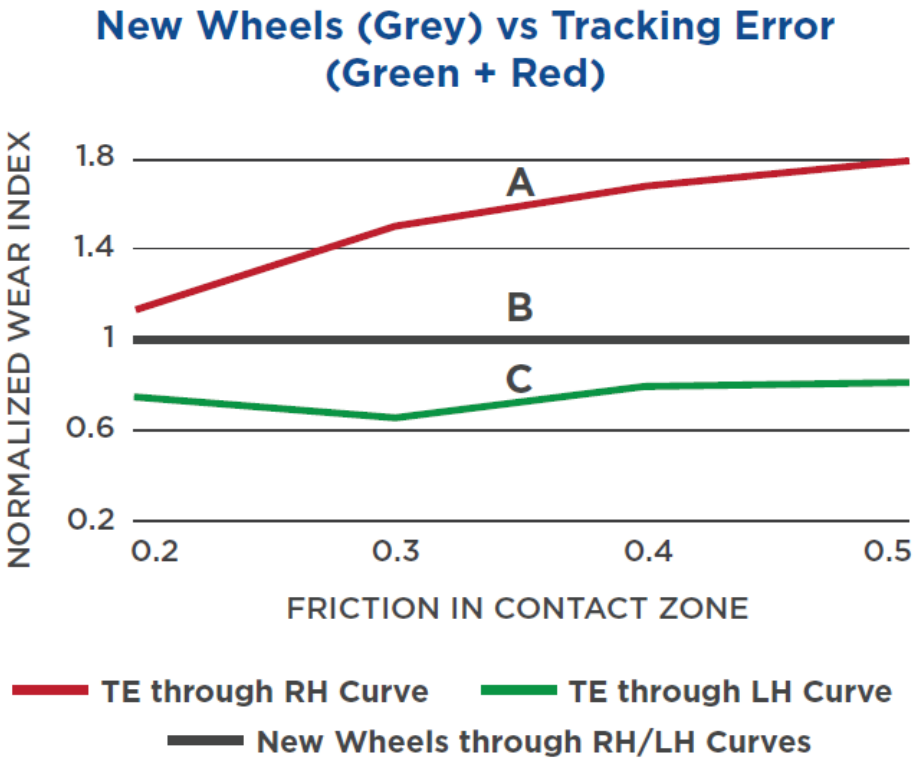


Above and Below Rail

- Combination of previous two slides, plus repeated flange impacts against the rail if severe hunting
- Accelerated degradation of whole system, both above rail and below rail
- Increased flange climb and derailment risk
- Propensity for spin creep and ‘scrubbing’ action against the rail

15





Izbinsky G., Sirois G., Liu Y., D'Aoust D., "Monitoring bogie performance on straight track. Part 1. Wheel set tracking position". The 7th World Congress on Railway Research, Montreal, June 2006

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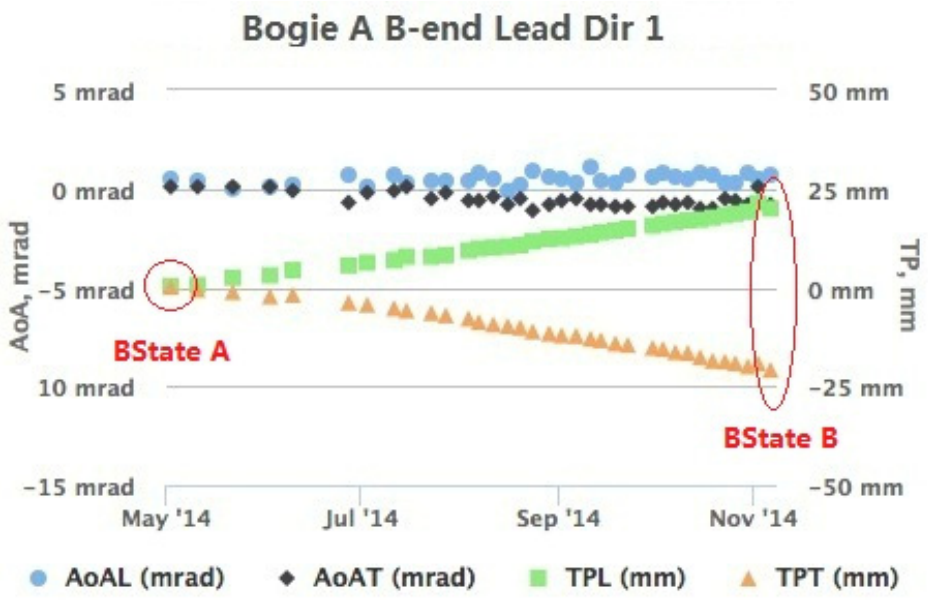
Targeted



Not to scale

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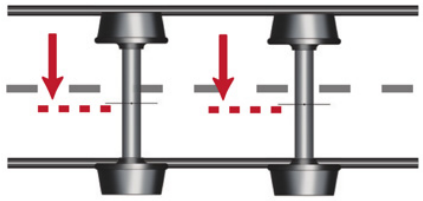
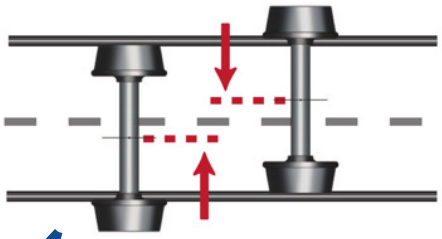
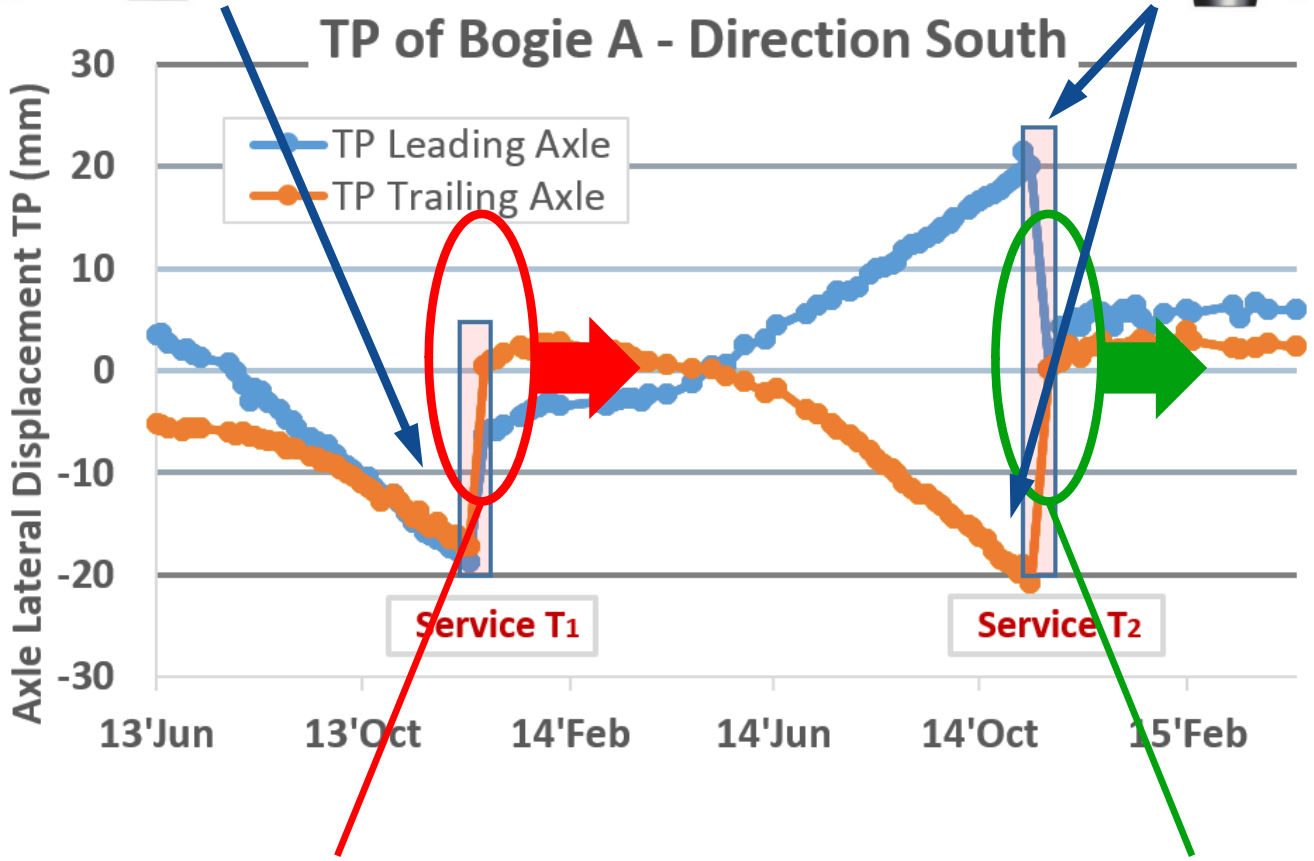
Targeted







Restored wheel profiles and bearings

Restored wheel profiles and bearings

Fixed brake beam and broken spring

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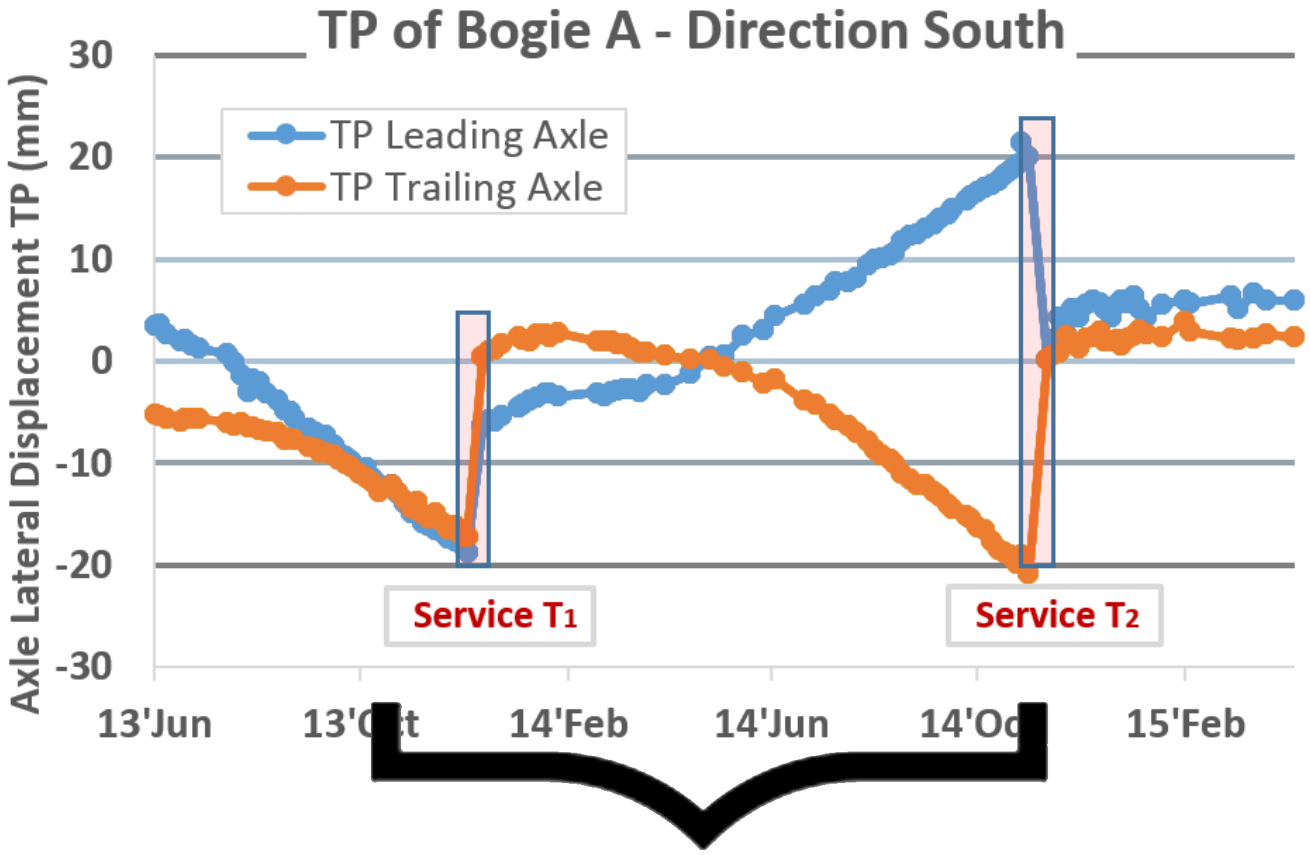

Unnecessary risk, wear, and fuel

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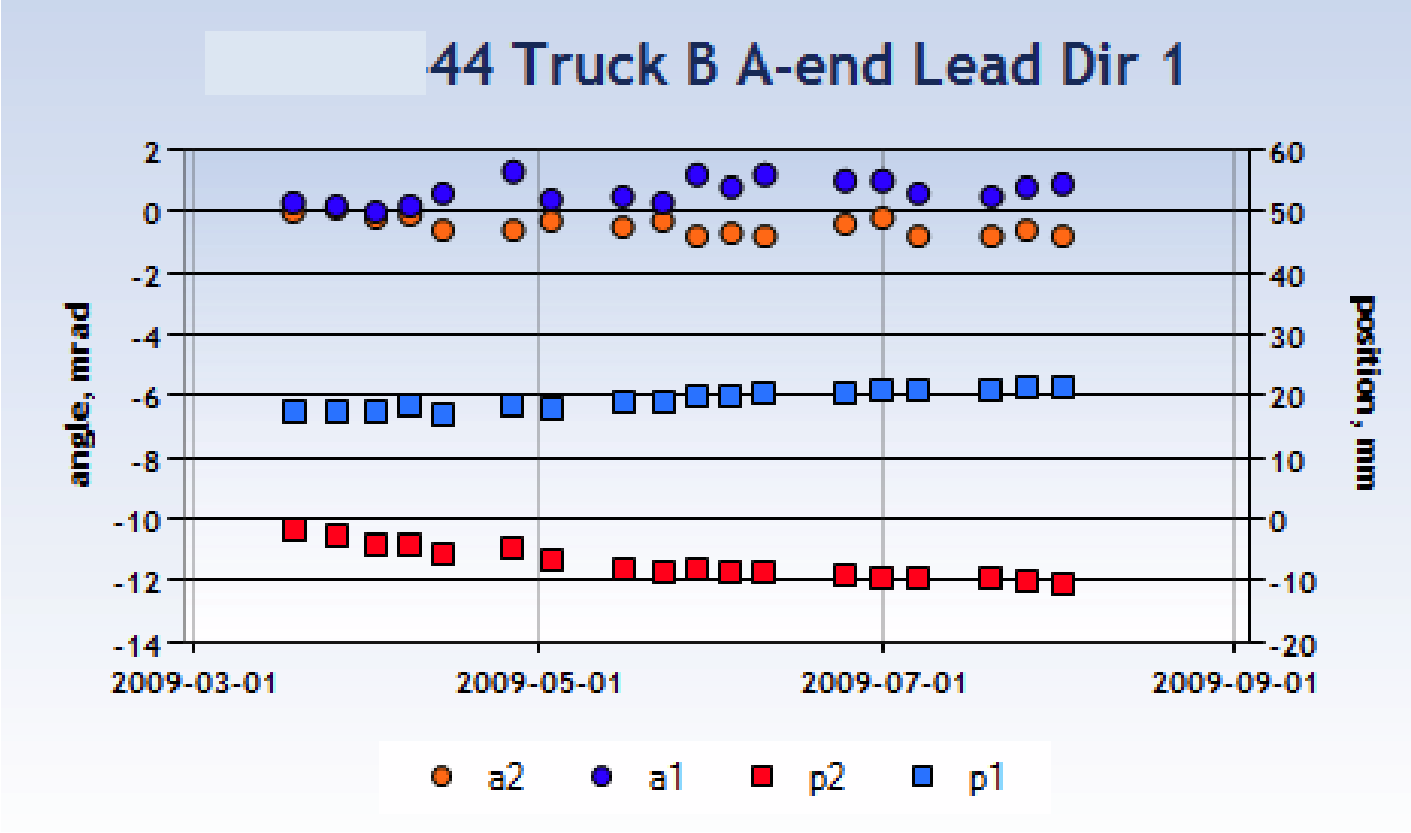

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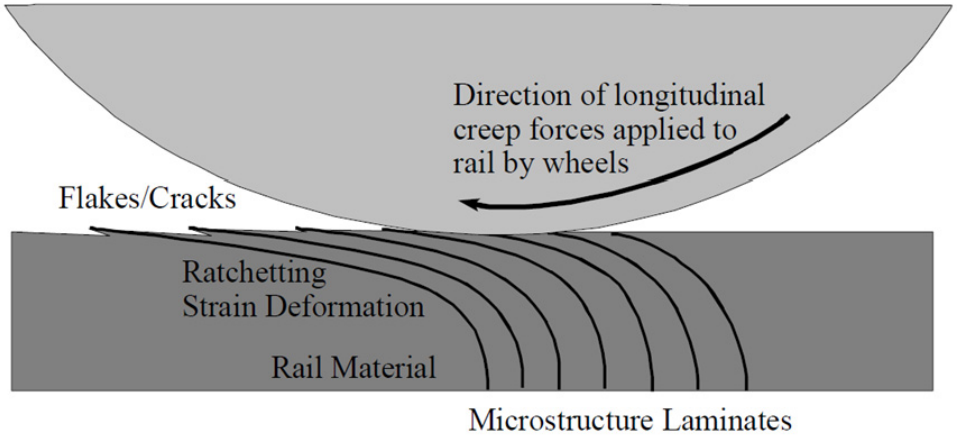

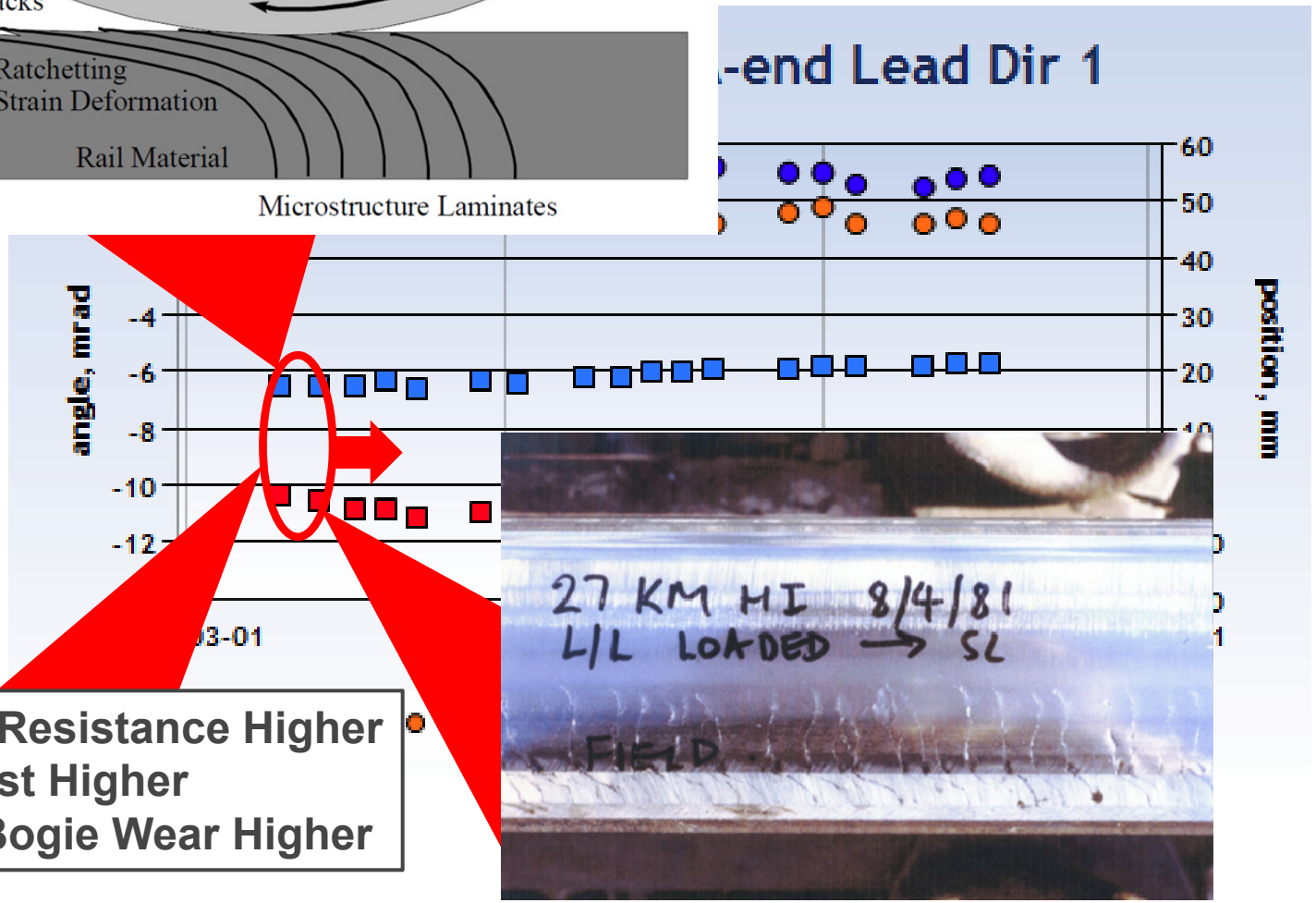

Rolling Resistance Higher
Fuel Cost Higher
Wheel/Bogie Wear Higher

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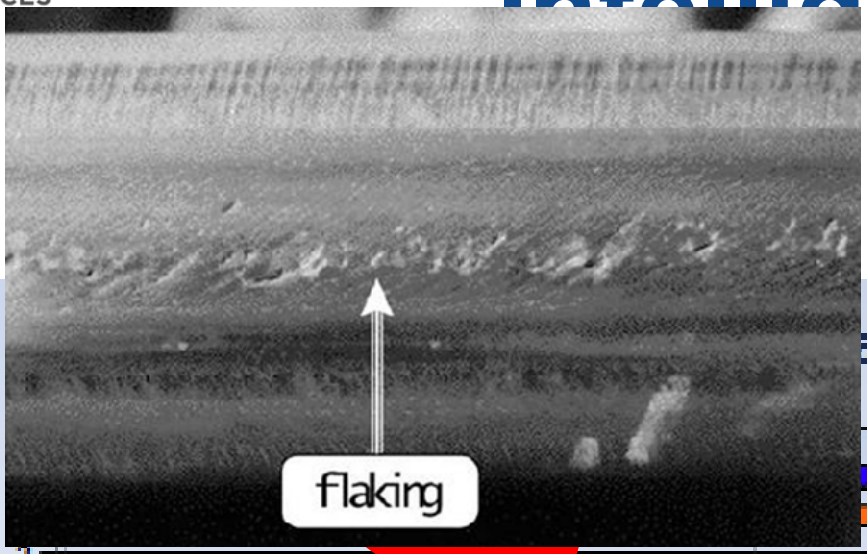

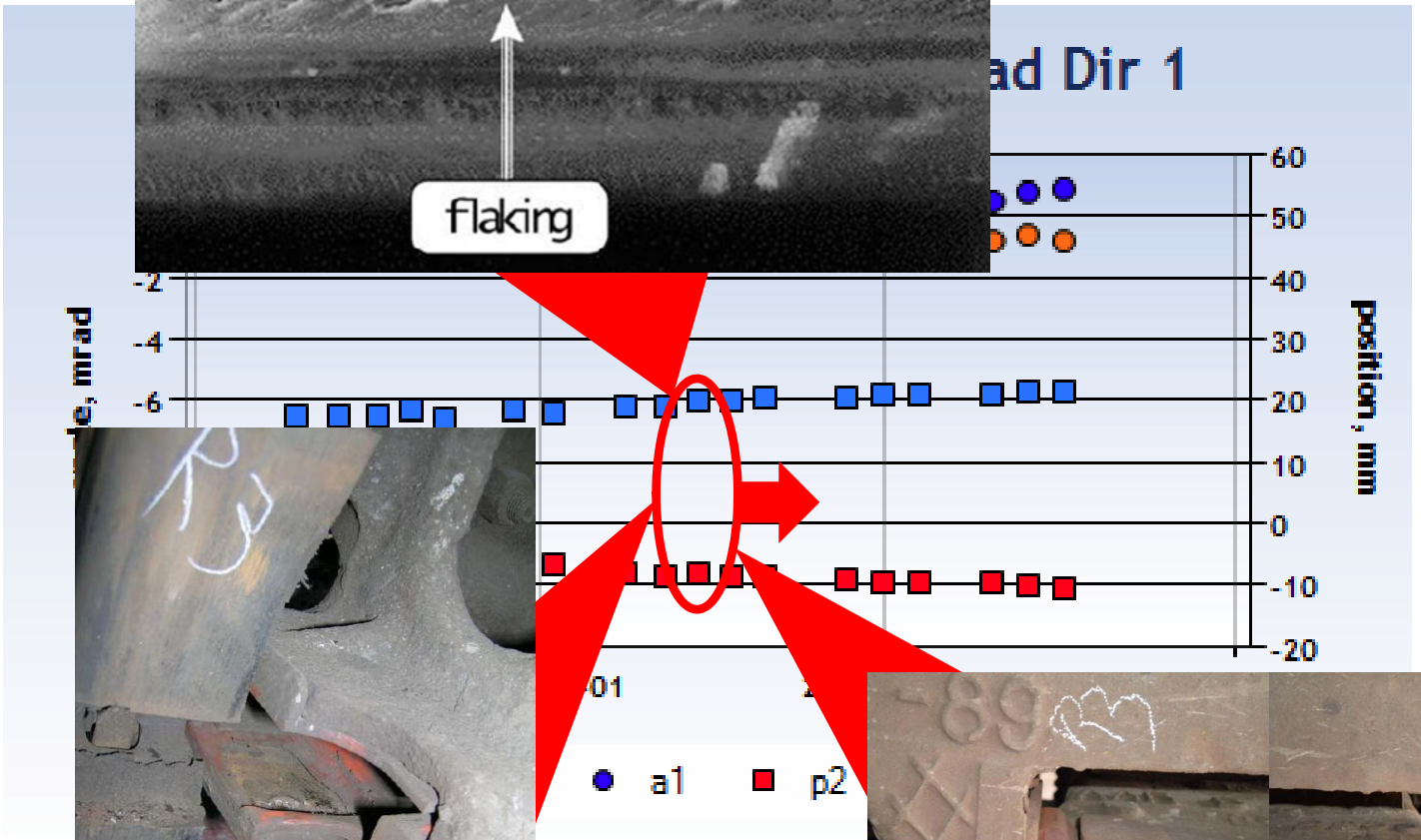

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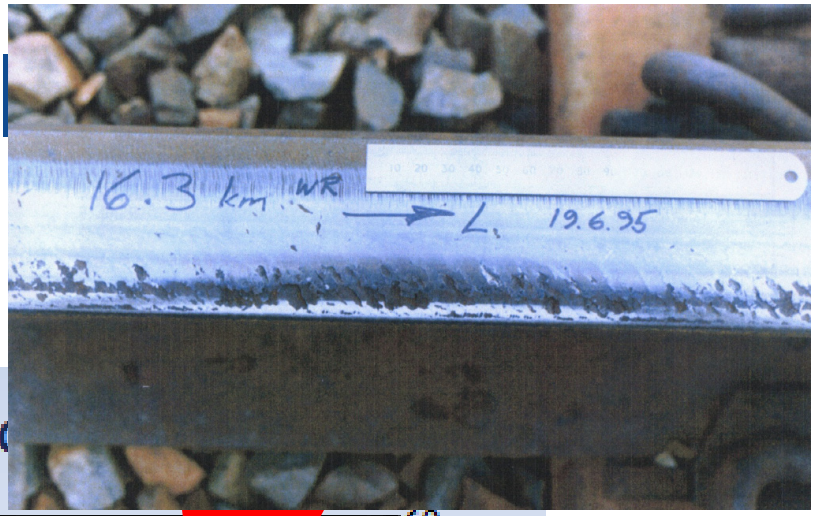

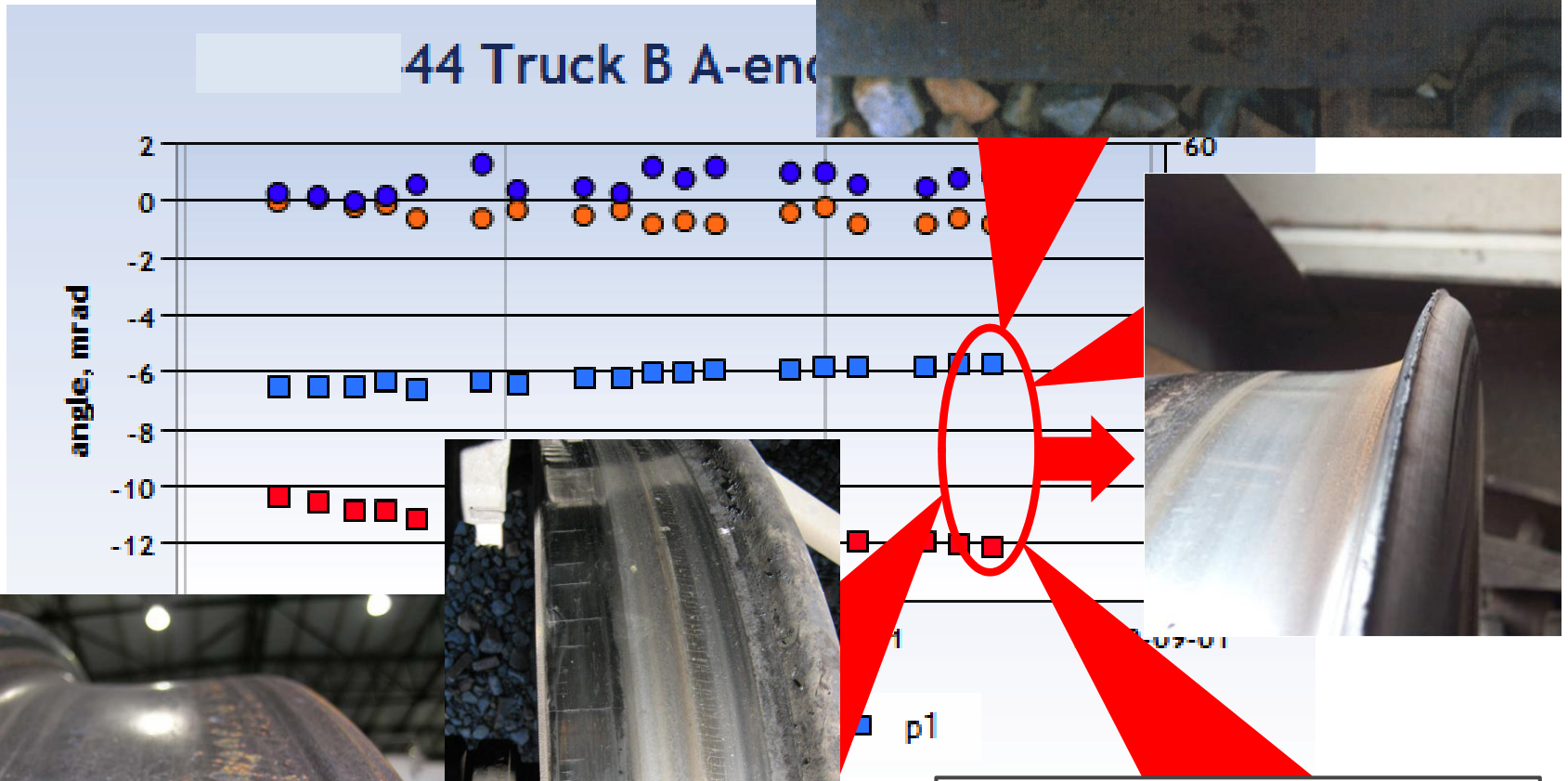

Fuel Cost 20% Higher
Wheelset Life 20% Shorter

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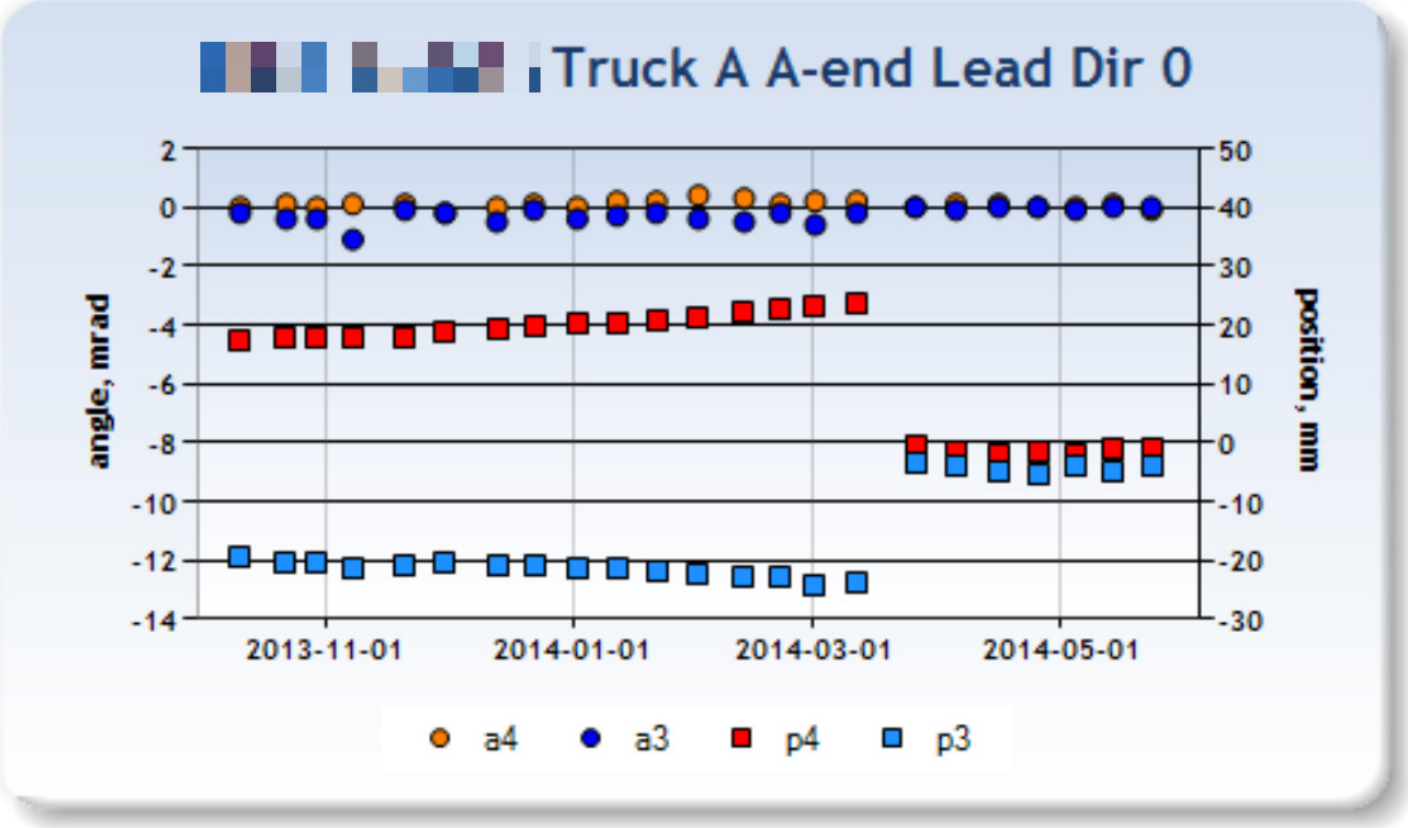
Tracking Error Case Study 2



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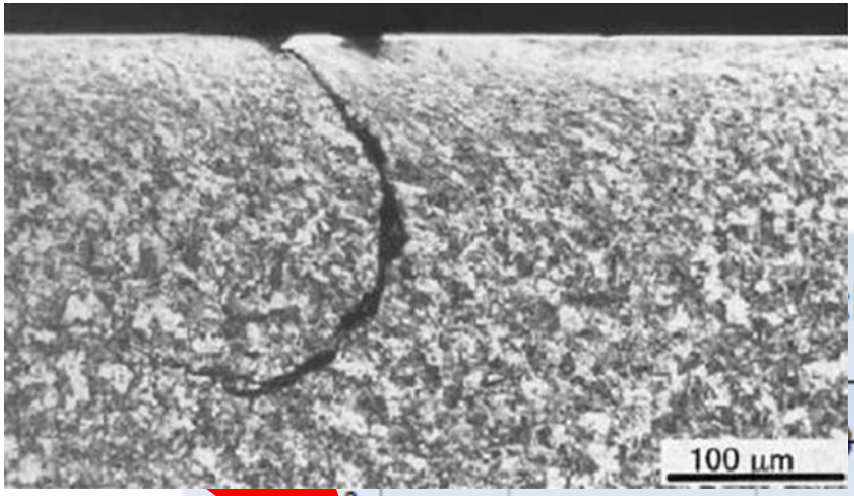

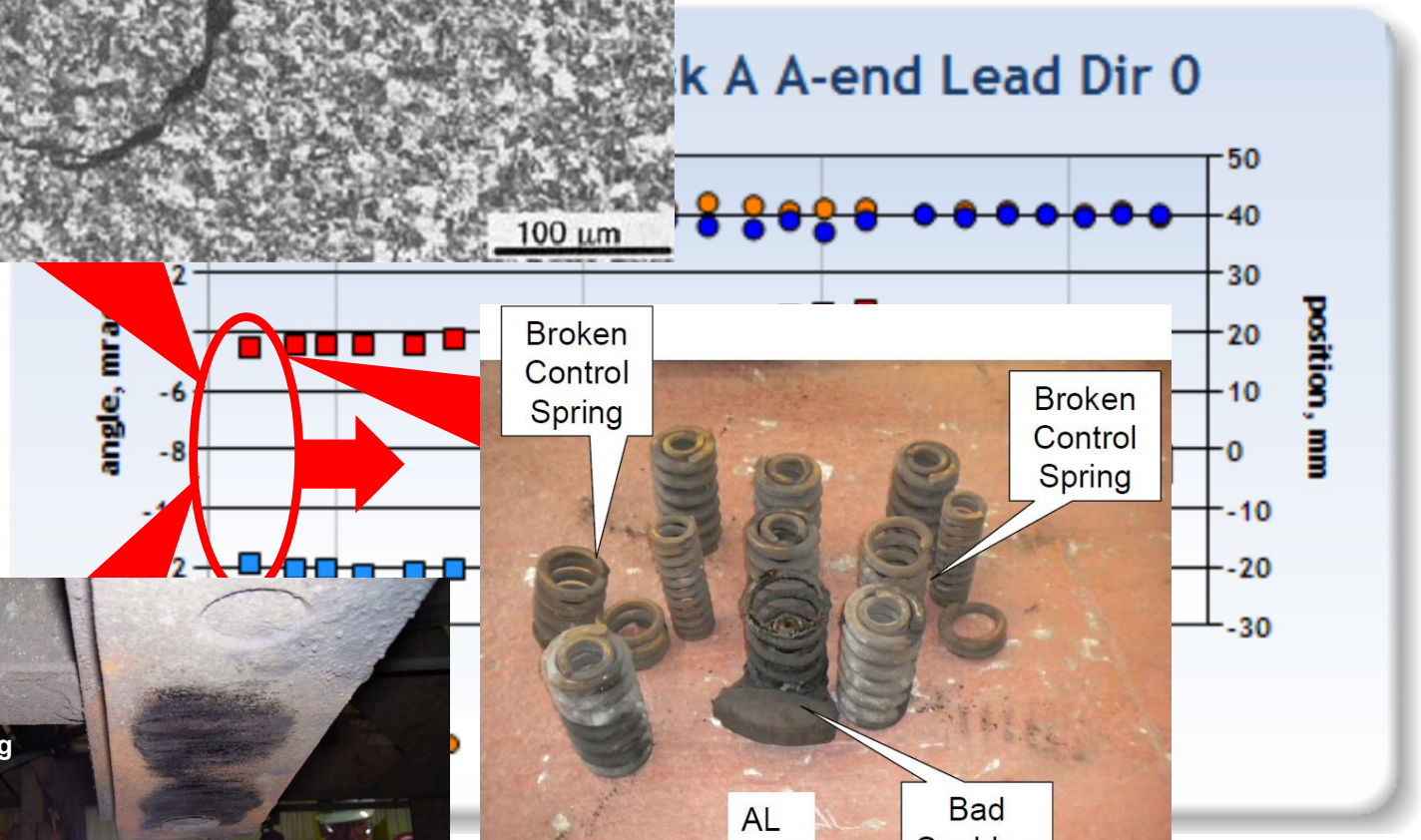

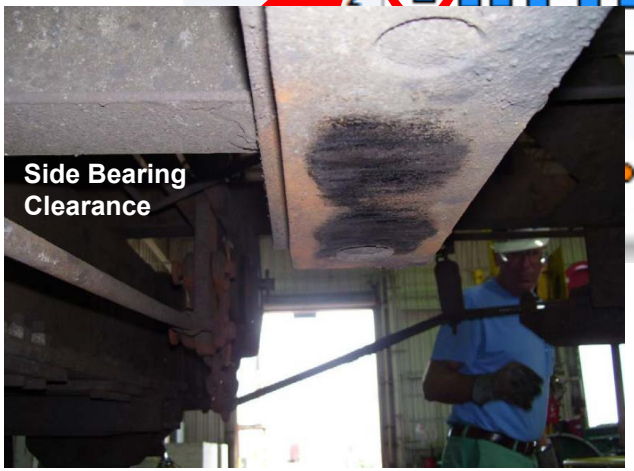

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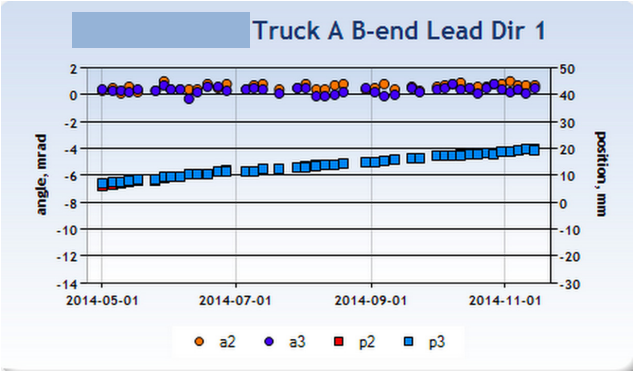
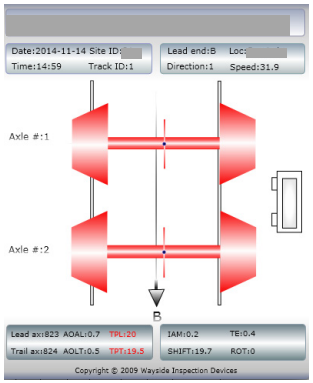
Figure 3. Circumferentially mismatched wheels (by 1.2 in) forced the axle to shift to a large tracking position of 32.3 mm (1.3 in) and caused an extremely thin flange on Car E.

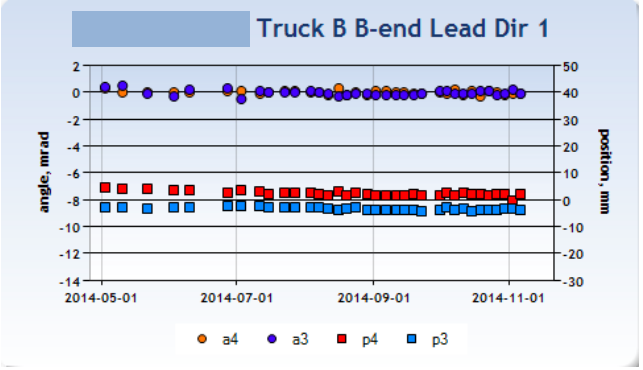
Cost to repair has become significantly higher

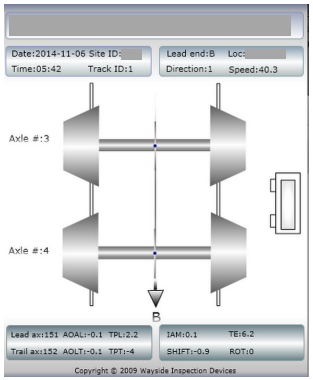
In this example:
Repaired only just in time - Reactive

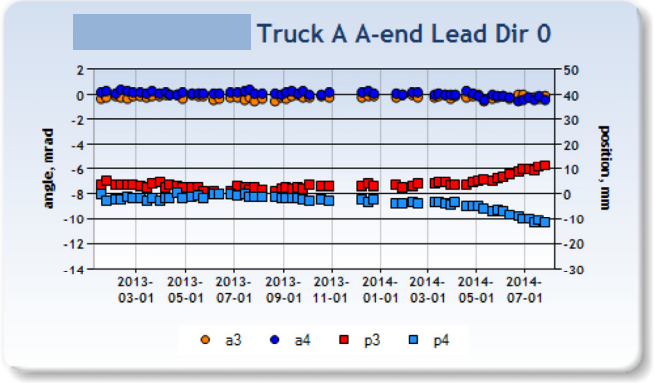
Accelerated Wear

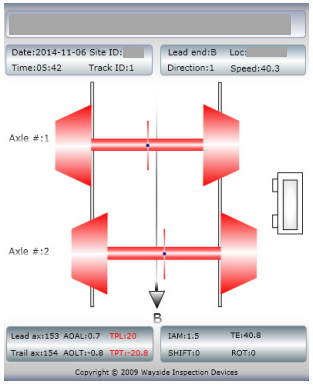












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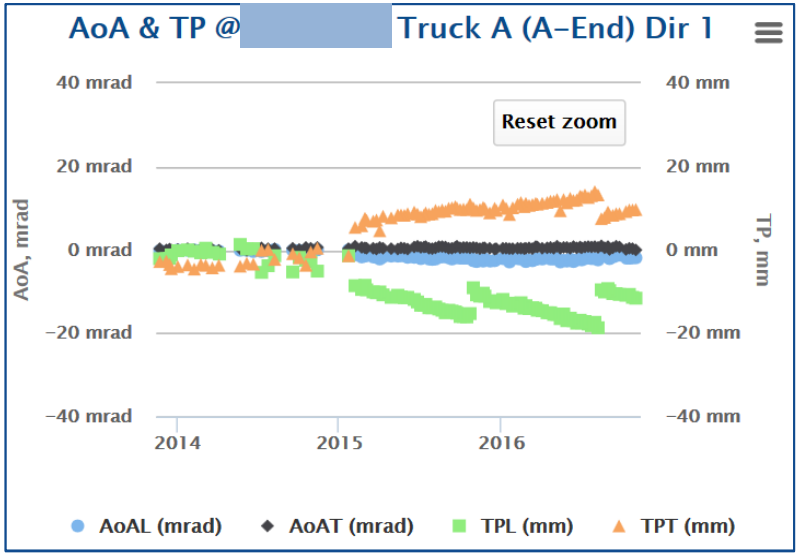
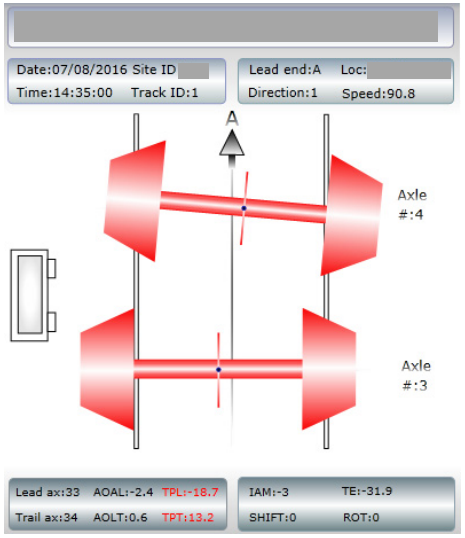
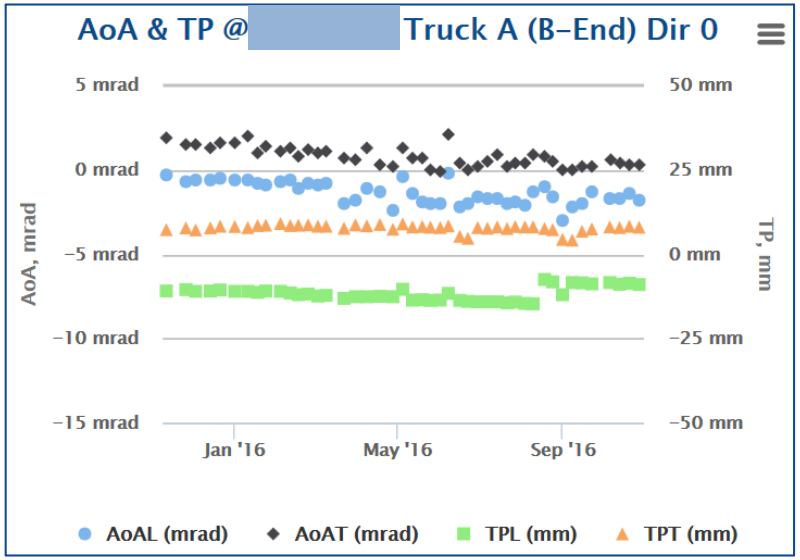
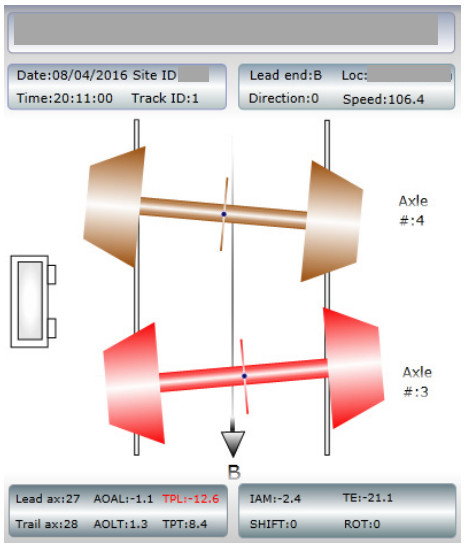
Accelerated Wear









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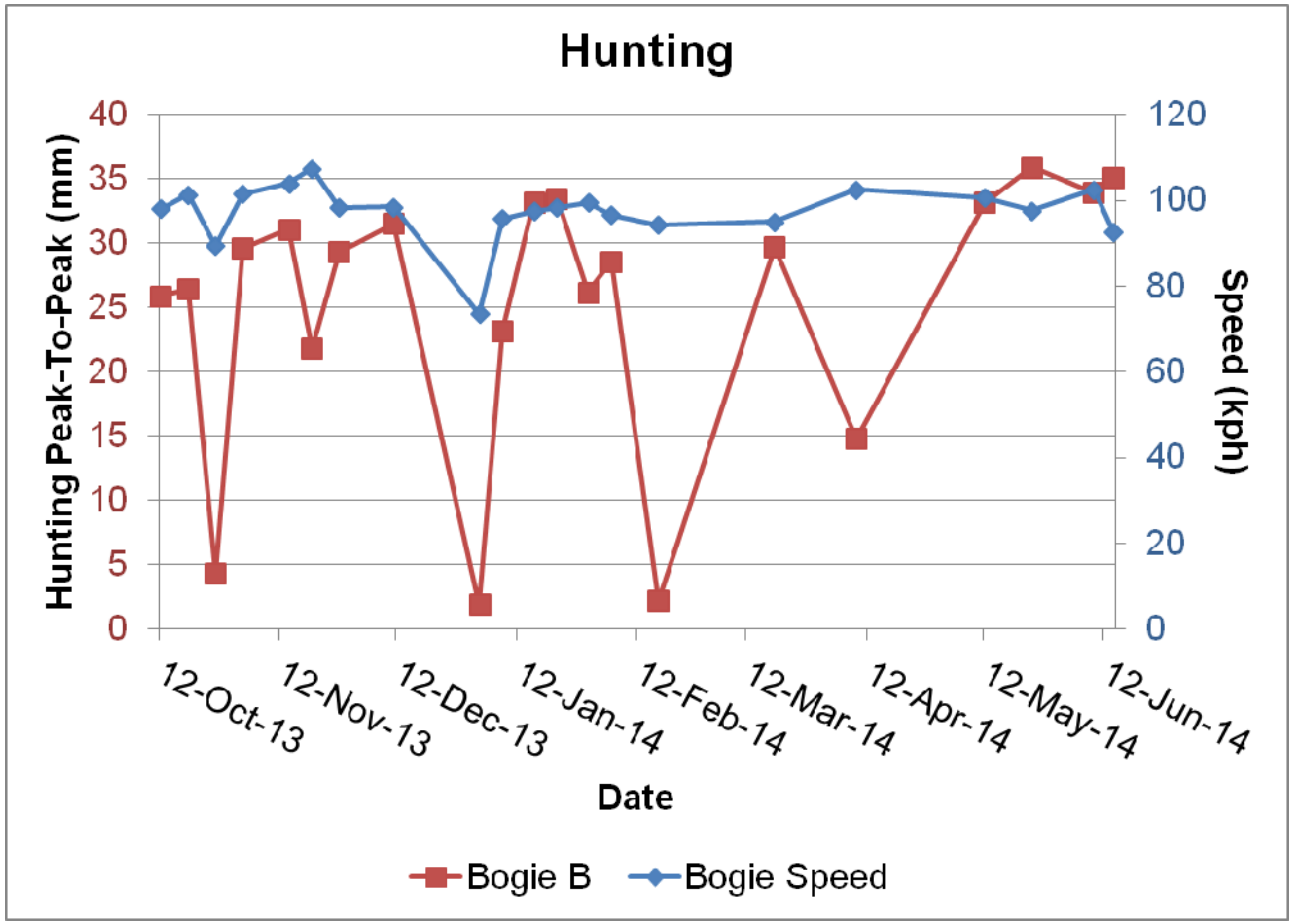
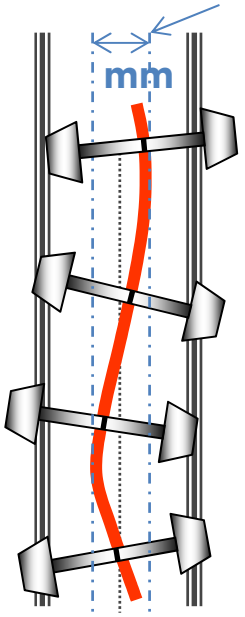
Hunting Case Study 1





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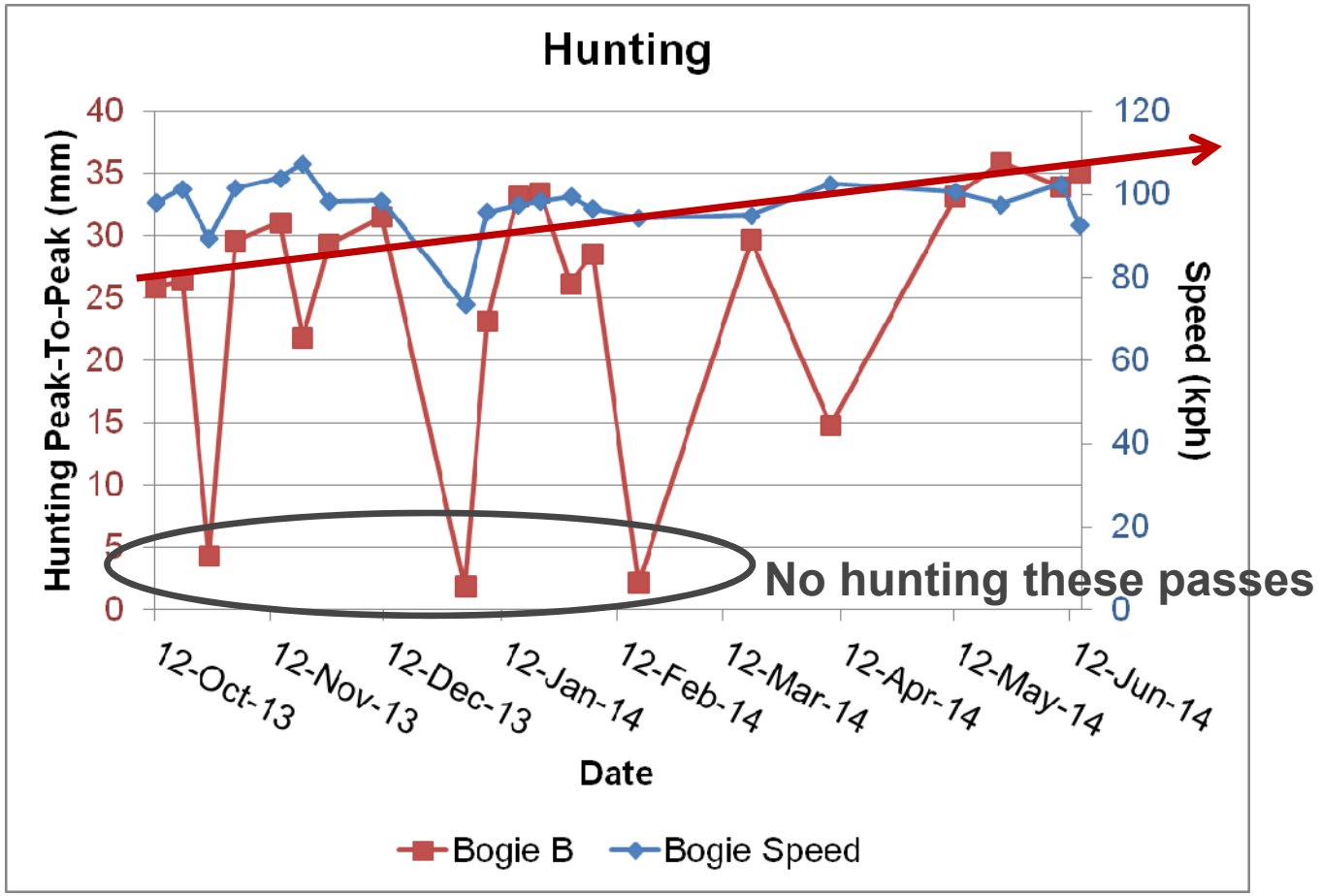

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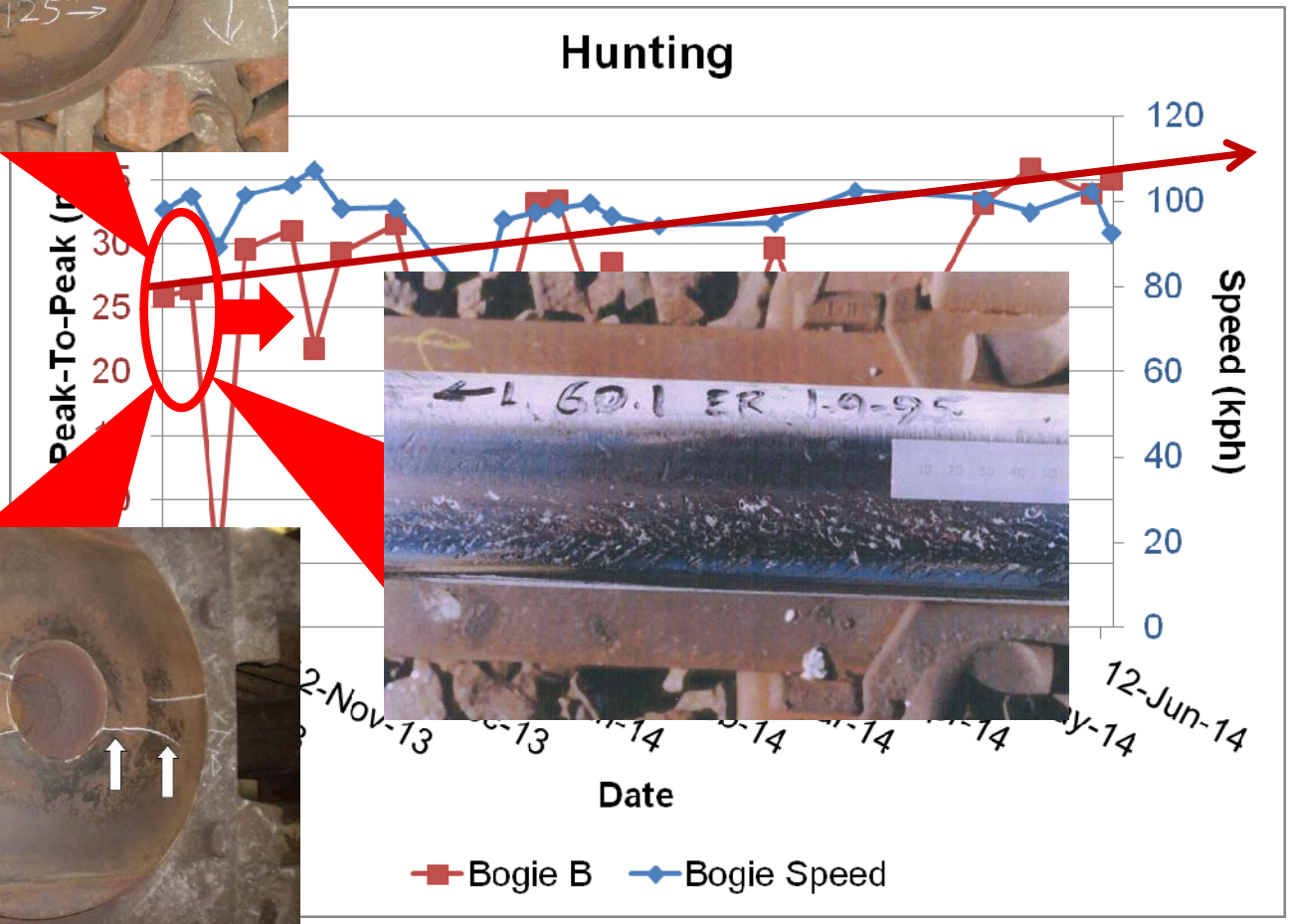

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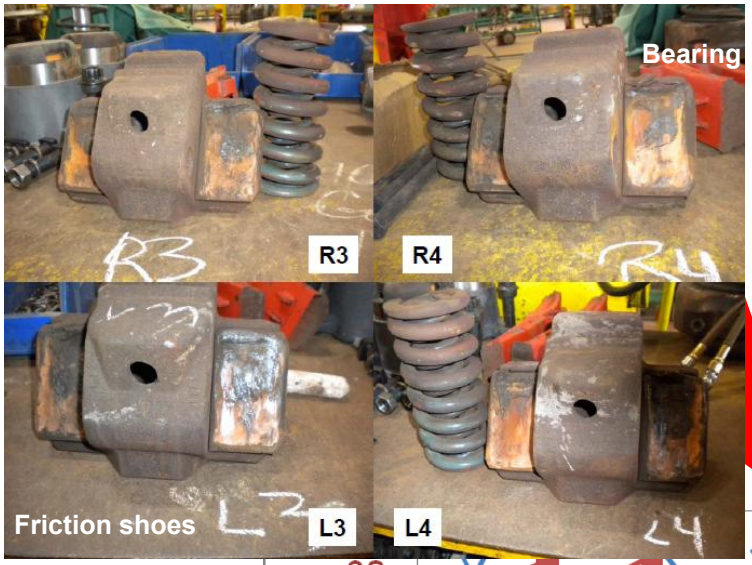

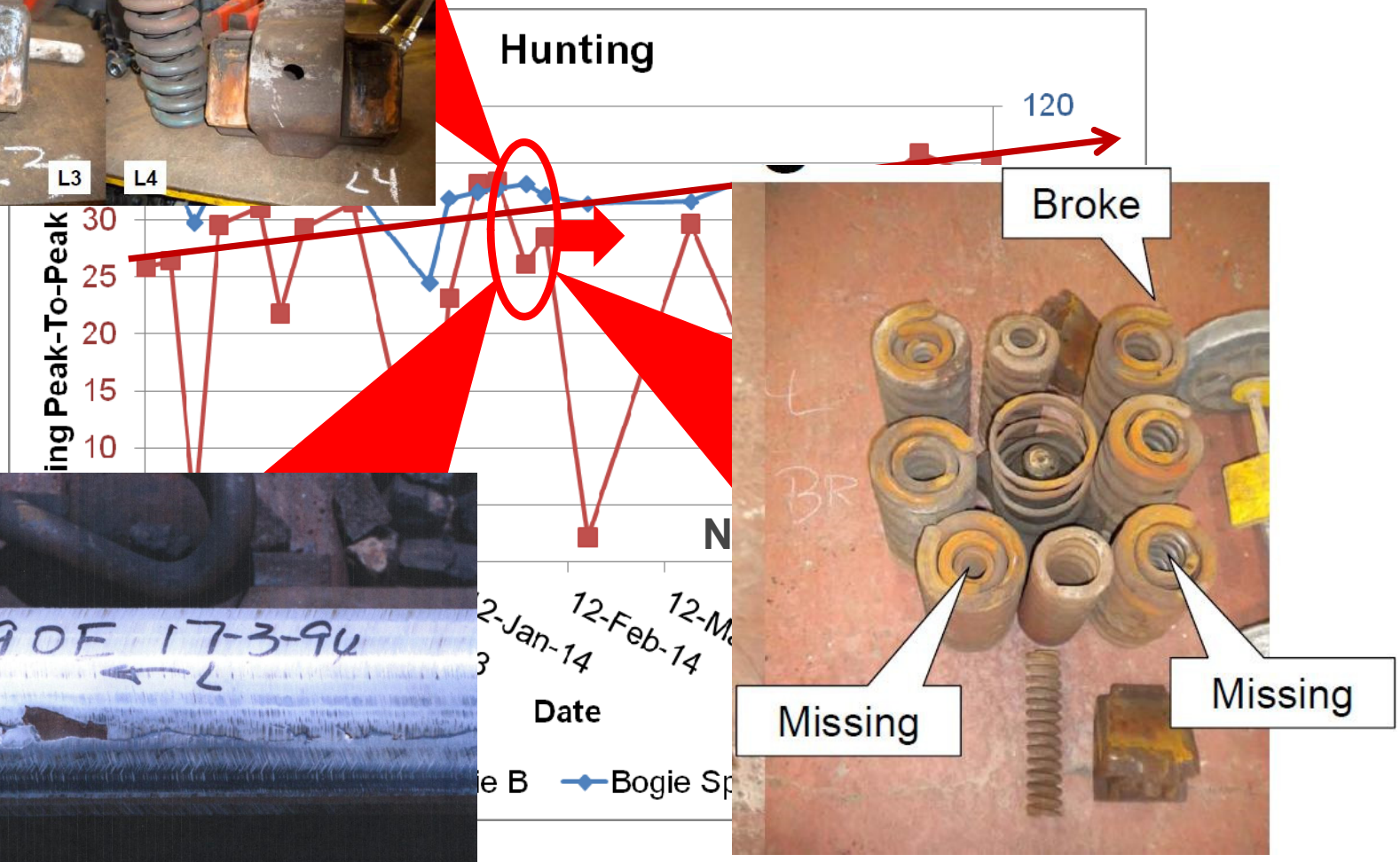

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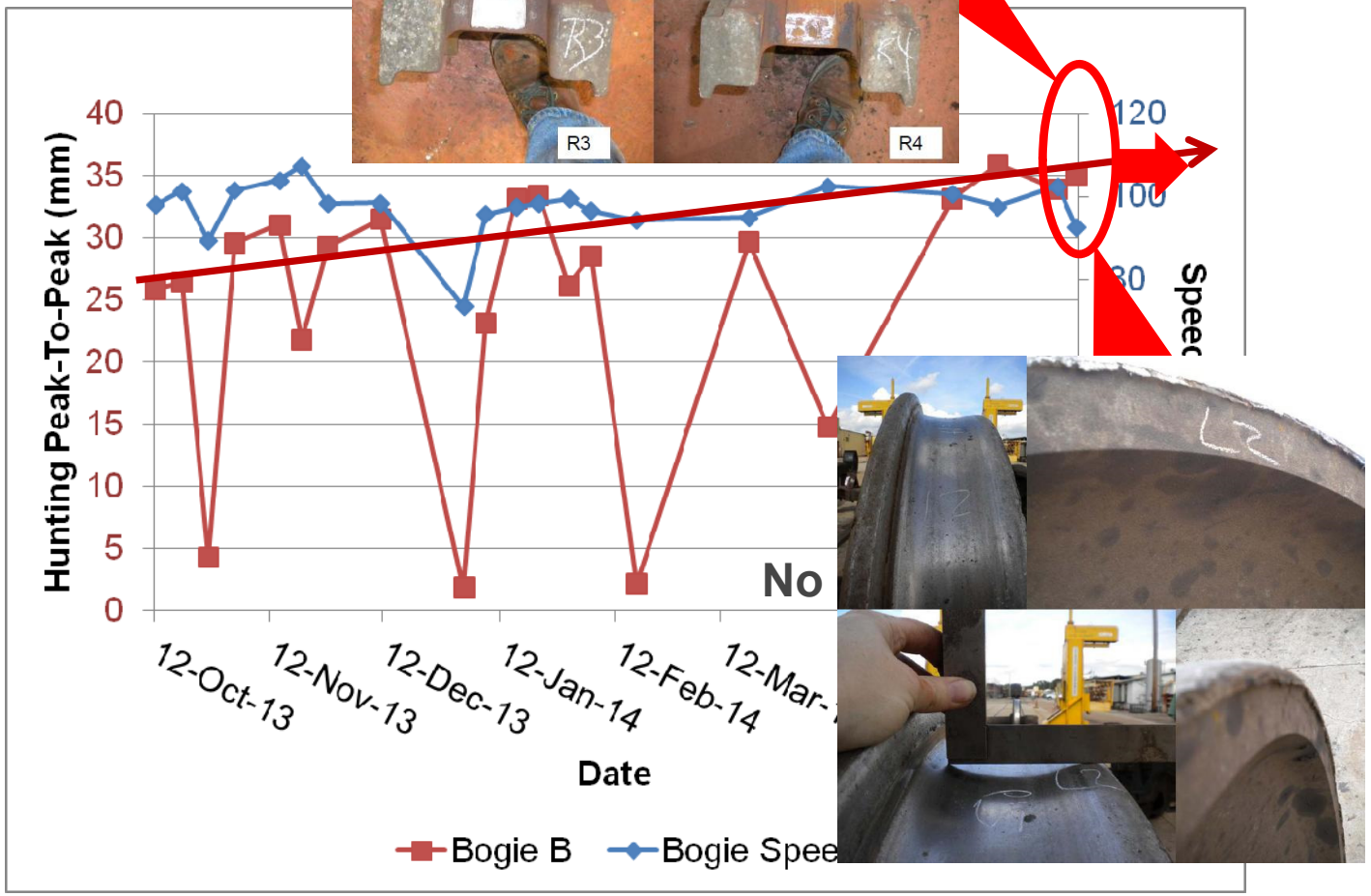

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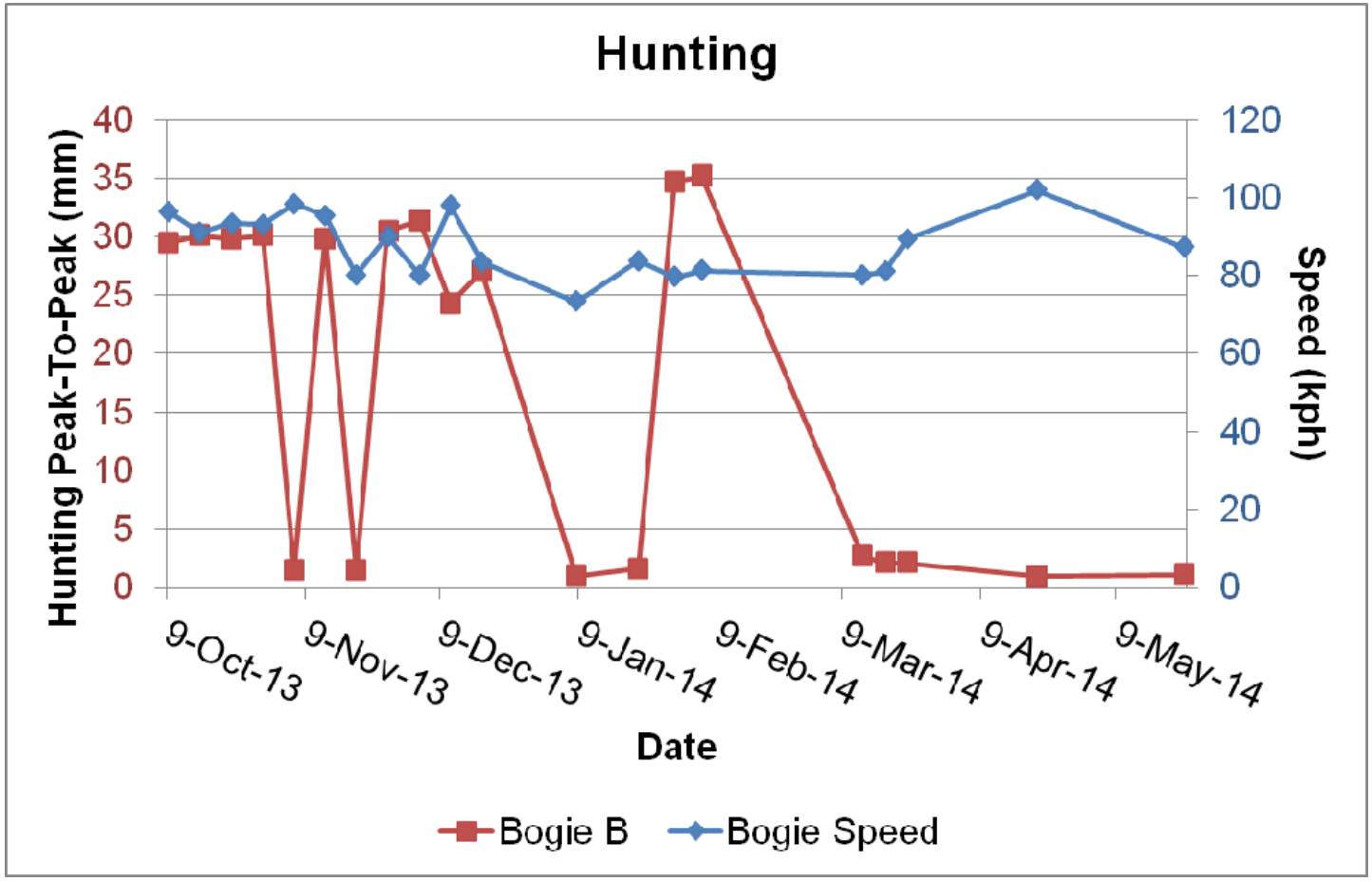
Intelligence

Hunting Case Study 2



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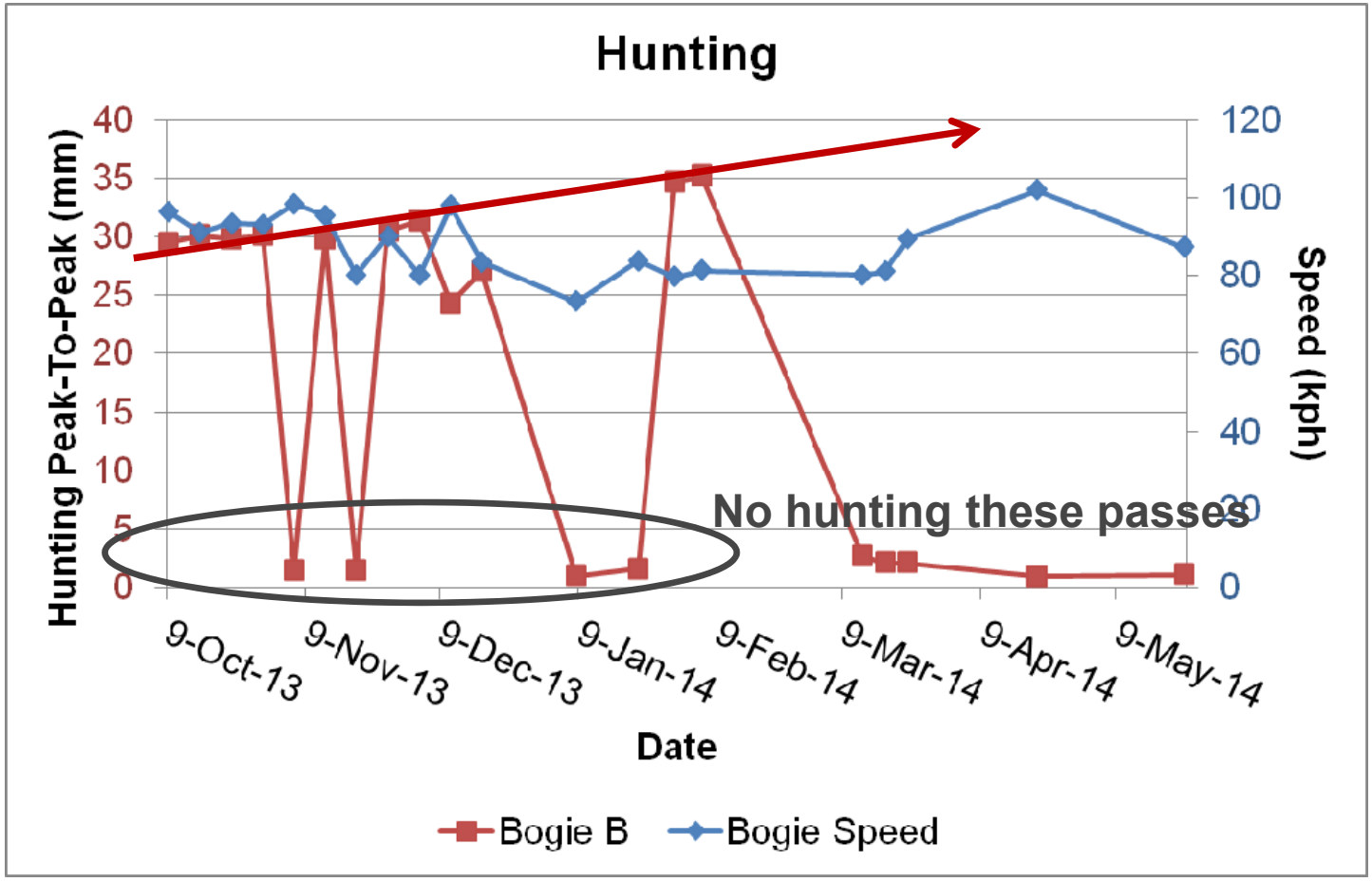
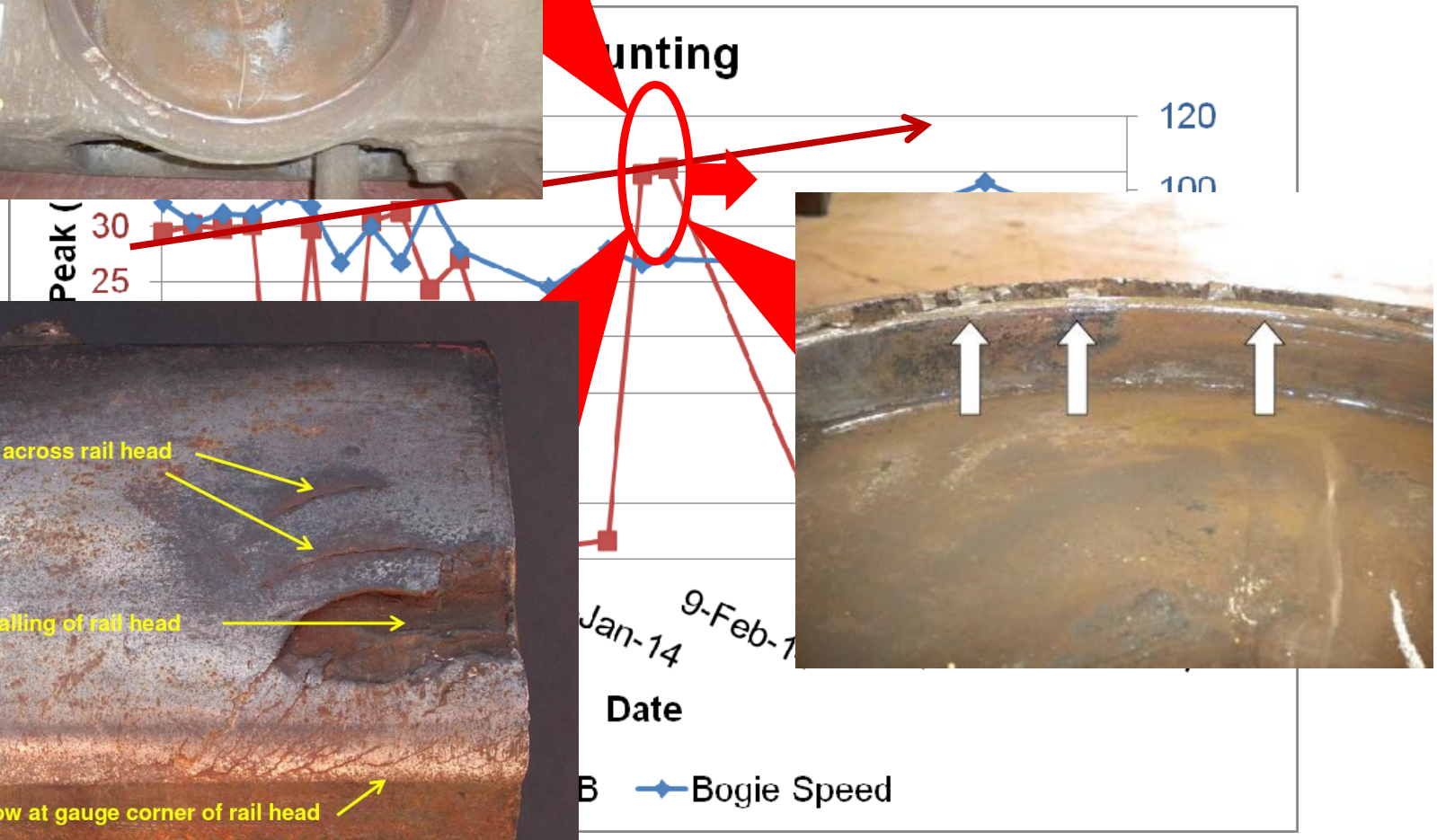
Intelligence



W ntelligence



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Intelligence

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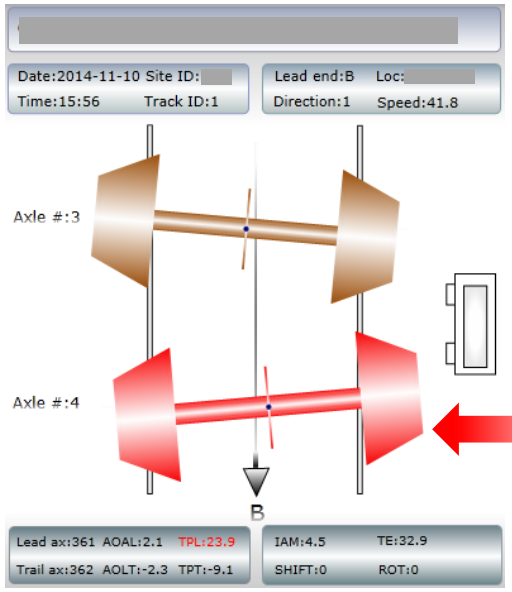
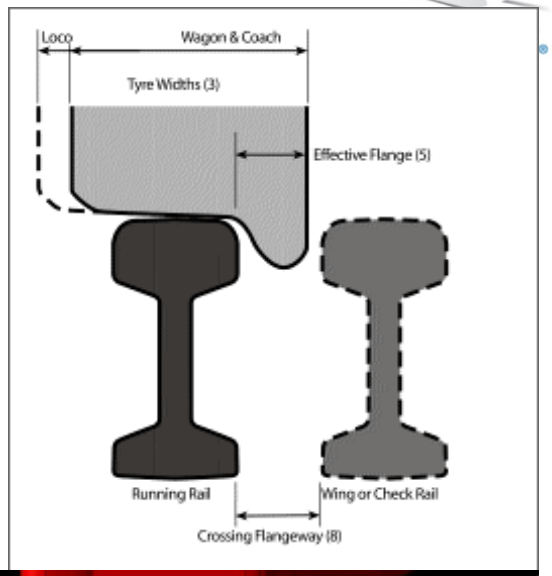
Turnouts

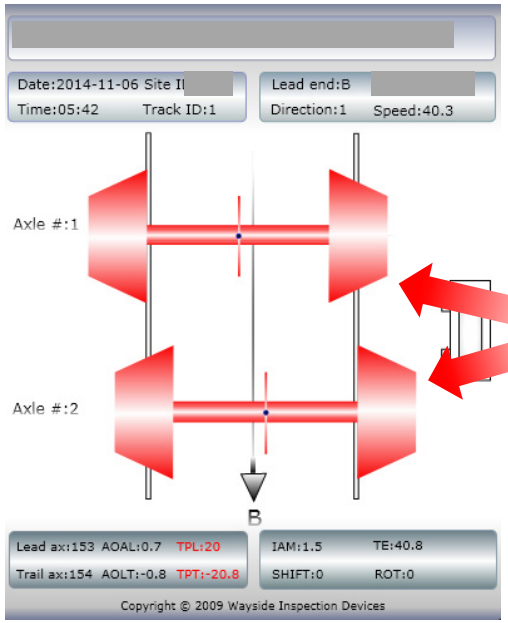


Flangeway = 45 mm
Typical flange = ~30 mm

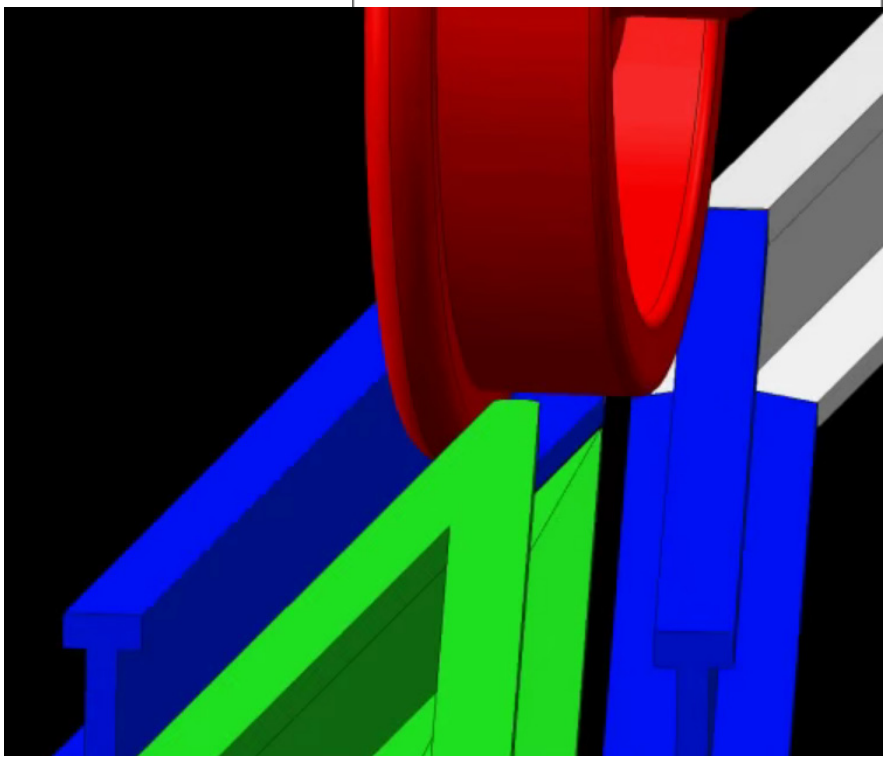
> ± 15 mm can make contact

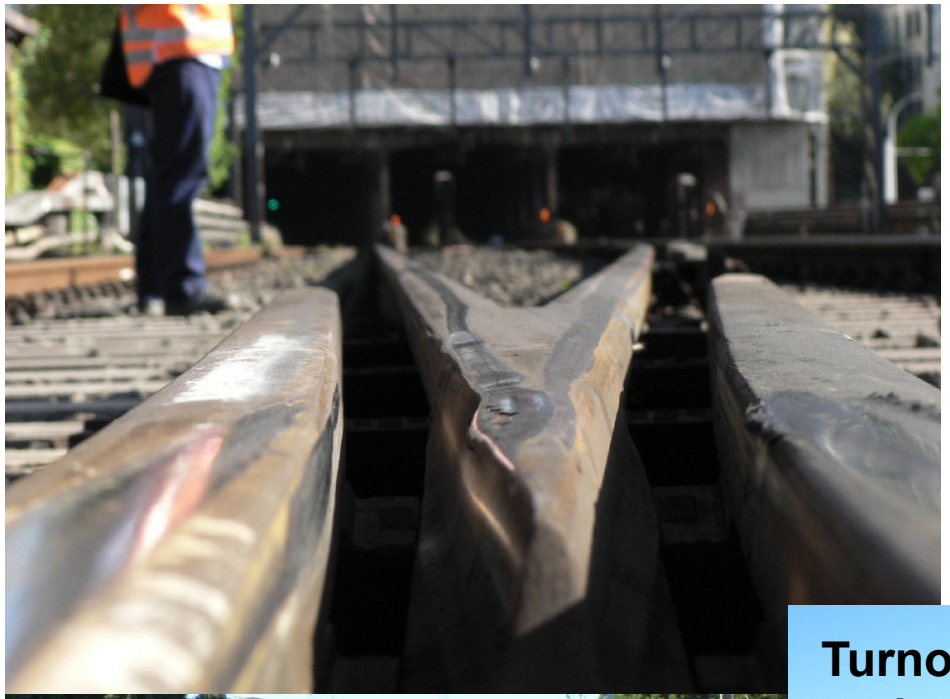
This wheelset > 23.9 mm and >9 mrad





Both > ± 20 mm





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Most common defects in turnouts are accumulated plastic deformation (lipping), wear, RCF, and rail head checking

Turnout when leading bogie steers one way and trailing bogie steers the other way

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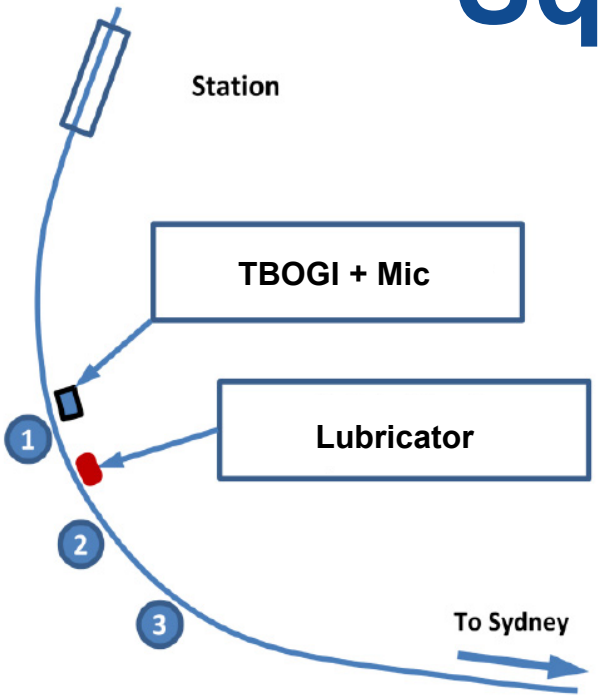
Squeal / Noise



The results show that all of the most severe wheel squeal events were generated by freight vehicles and that nearly all of these were associated with abnormally high AoA.

This shows that the curving performance of wagons plays an important role in squeal.

Transport for New South Wales (NSW), Australia. World Congress on Railway Research, Sydney, 2013

The likelihood of squeal increases if AoA exceeds 10 mrad

Large AoAs (much higher than 10 mrad) frequently from freight trains and were responsible for high level squeal

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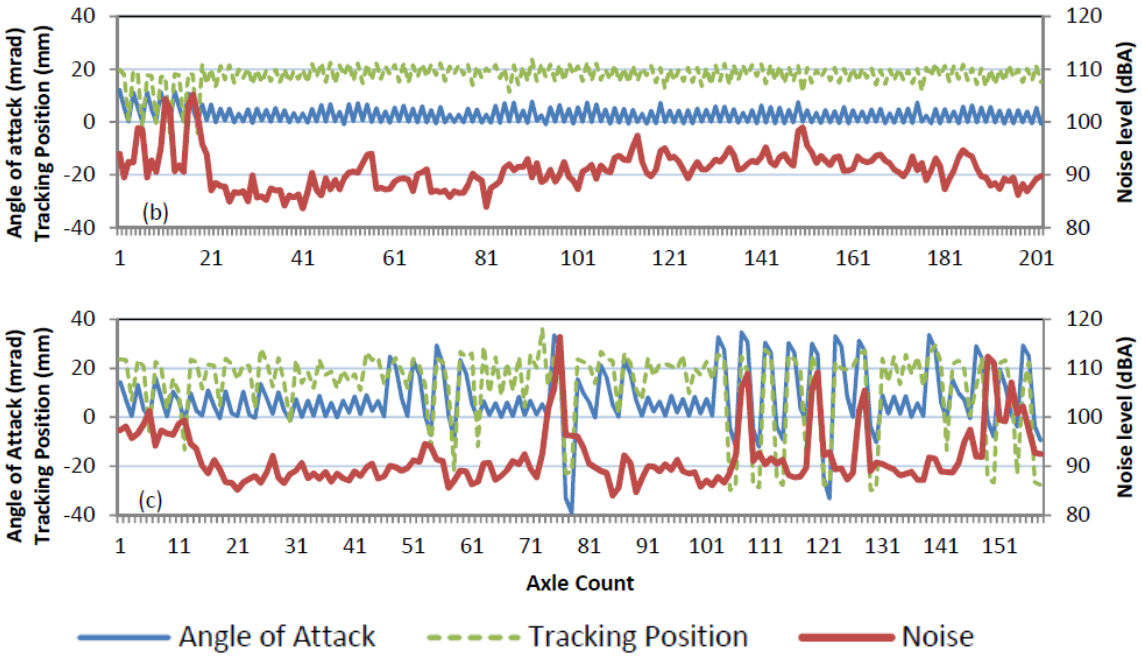
Squeal / Noise



The Impact of Angle of Attack on Curve Squeal, Transport for NSW and University of Wollongong. World Congress on Railway Research, Sydney, 2013

Table 2 Normalised squeal occurrence rates

	Squeal Category	Squeal occurrence rate	
		Per train	Per day
Passenger	>120	0.00%	0
	110-120	1.02%	1
	100-110	15.15%	18
Freight	>120	35.98%	4
	110-120	46.95%	5
	100-110	99.39%	10

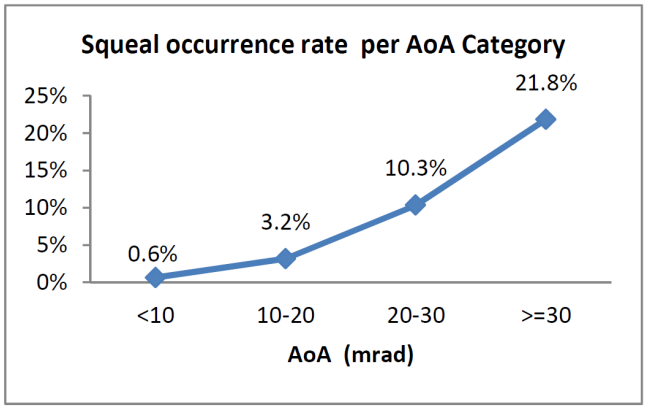


Figure 3 Freight train squeal occurrence rate per AoA category

Wheel squeal ⇔ AoA **Flanging noise ⇔ TP**

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Squeal / Noise

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Improving the Wheel-Rail Interface

Derailment Prevention

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Improving the Wheel-Rail Interface

Above Rail

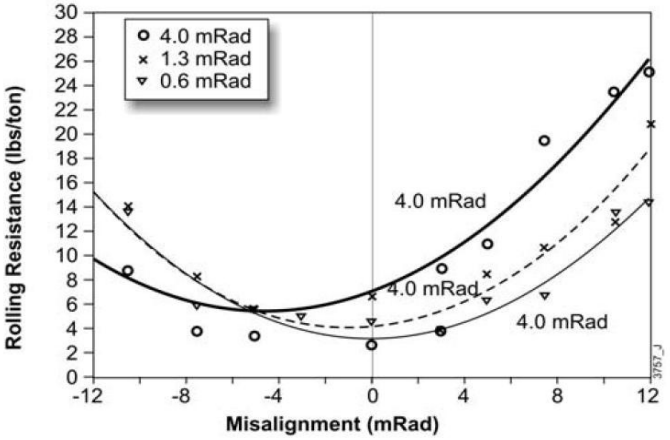

Figure 9

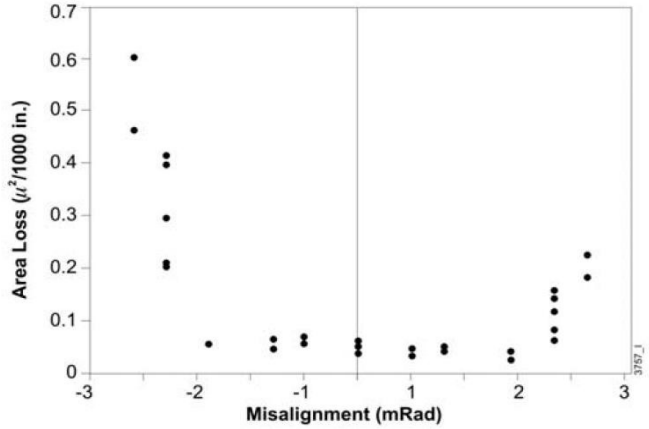

Figure 5

Below Rail

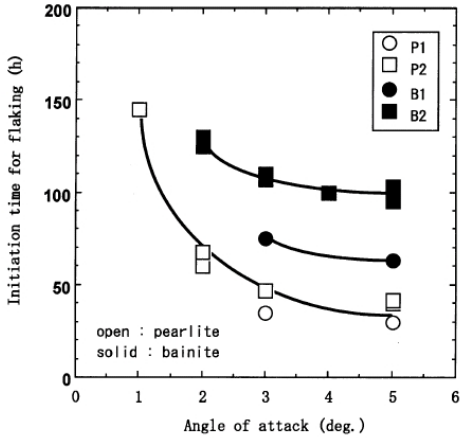

Fig. 7. Effects of the angle of attack on the life span before flaking.

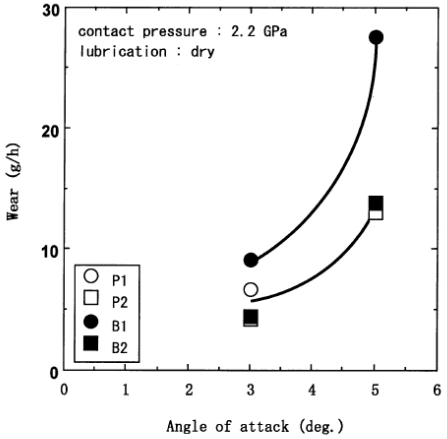

Fig. 13. The effect of the angle of attack on wear.

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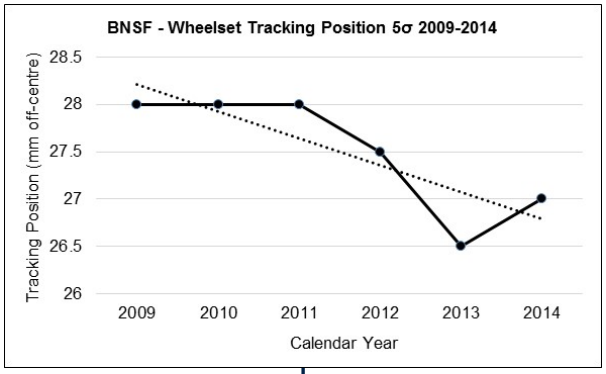
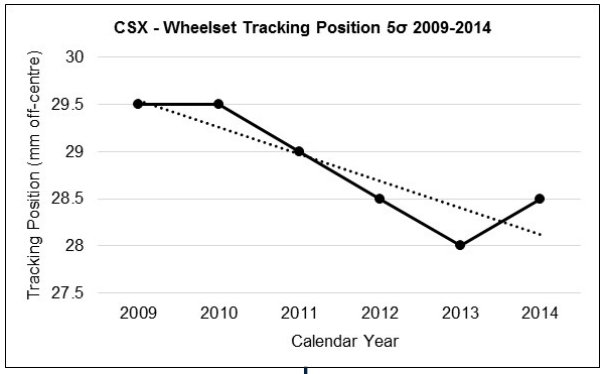
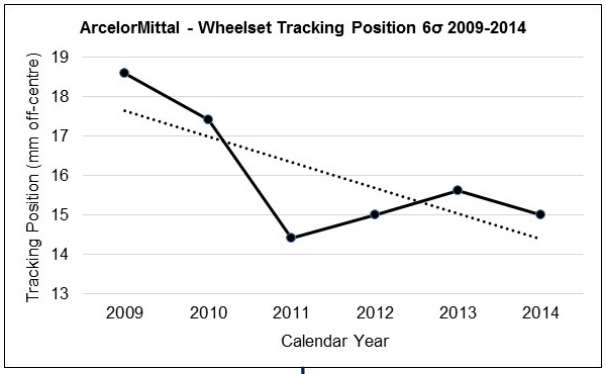
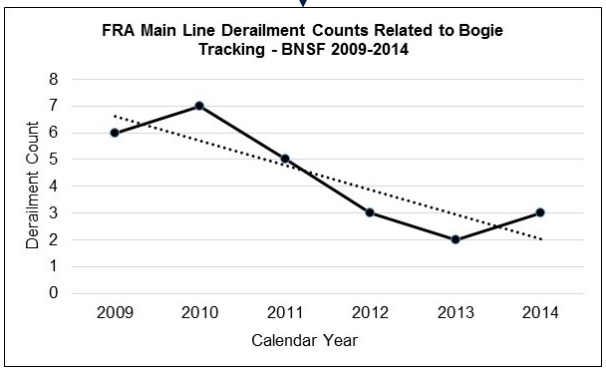
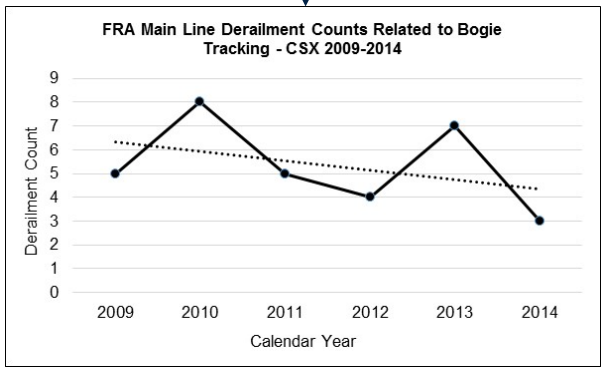
Derailment Prevention











ArcelorMittal is able to maintain bogie defects below thresholds such that they have not experienced derailments related to bogie geometry or tracking defects since 2003

Excerpts from Bladon, P., K. Bowling, H. Braren, J. Deslauriers and D. D'Aoust 2015 "The Challenges of Integrating Novel Wayside Rolling Stock Monitoring Technologies, A Case Study." In, Proceedings of 2015 International Heavy Haul Conference, Perth. International Heavy Haul Association (IHHA), 417-426.

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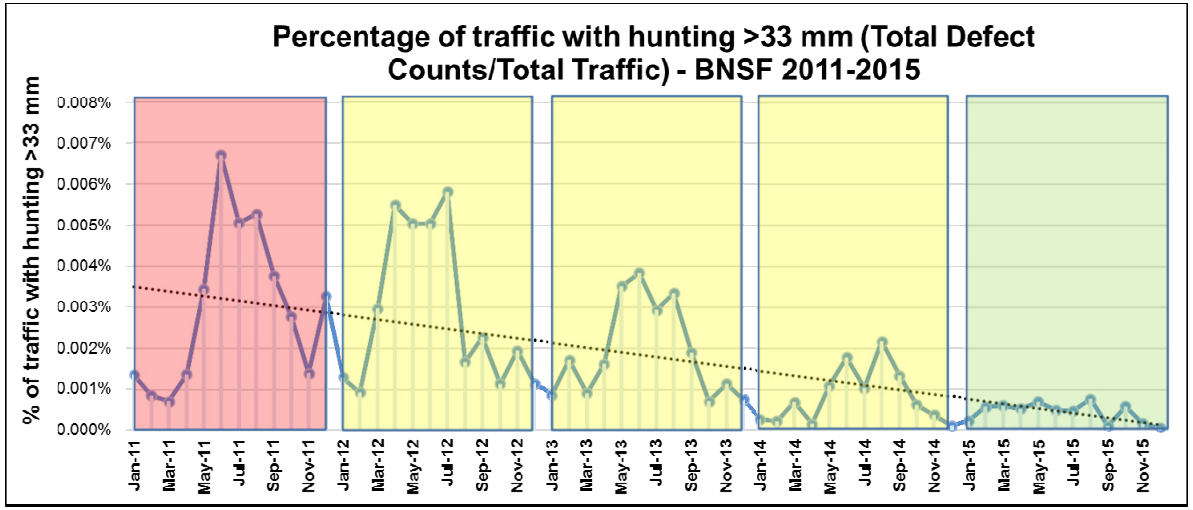
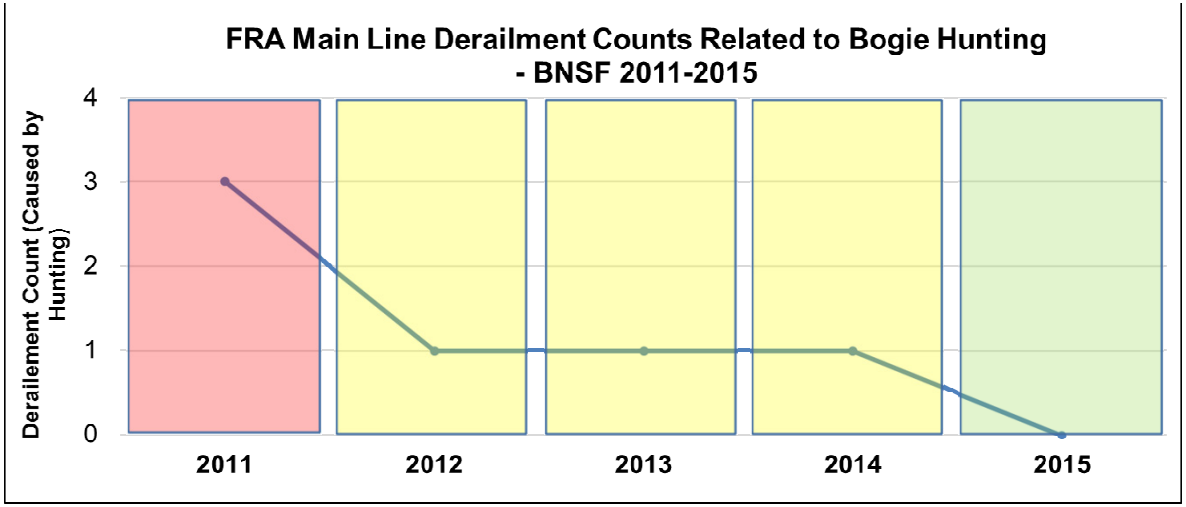
Derailment Prevention





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Where to now

Improving the utilization of modern Bogie Performance Detectors

Ongoing development of granular composite rules - more targeted alarms

Ultimately:

- **Virtual roll-by the trains before they arrive**
- **Integration of wayside data with track data - know not to run certain bogies on certain track**


Thank you!