

# Hunting at Vale EFC

**Case study of bogie hunting at Vale EFC between 2009 to 2017, and the inter-relationship between track and rollingstock**

**Paul Bladon, Denis D'Aoust, Pedro Freire**



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# Acknowledgements

Wayside Inspection Devices Inc (WID) would like to thank the following contributors:

- Pedro Freire, Vale
- Jun Kina, Vale
- Evgeny Adanichkin, Track IQ



# Vale EFC (São Luís Line)



# Vale EFC (São Luís Line)

## Carajás Railway:

- The line is 892 km long, TR68 (136 lbs)
- Broad gauge 1.60m, rail head profile unchanged since 2009
- Runs from Carajás Mine to São Luís Port
- Carajás Mine is largest iron ore mine in the world

## Rolling Stock:

- Iron ore trains typically 330 cars long, sometimes 340
- Axle load = 31.5-37.5 tonnes
- Loaded trains = 41,000 tonnes
- Trains use 2x1x1 or 1x1x1 loco set up





# Vale EFC (São Luís Line)



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# São Luís Line - Brazil



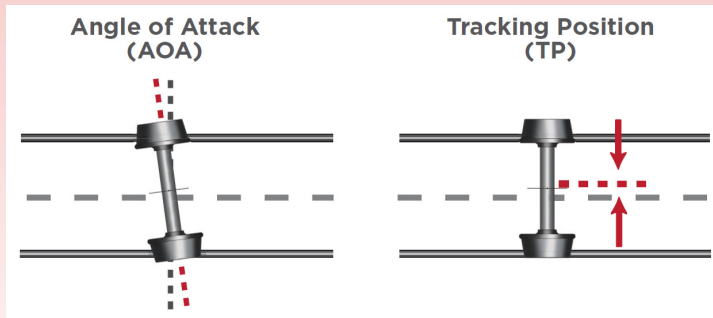
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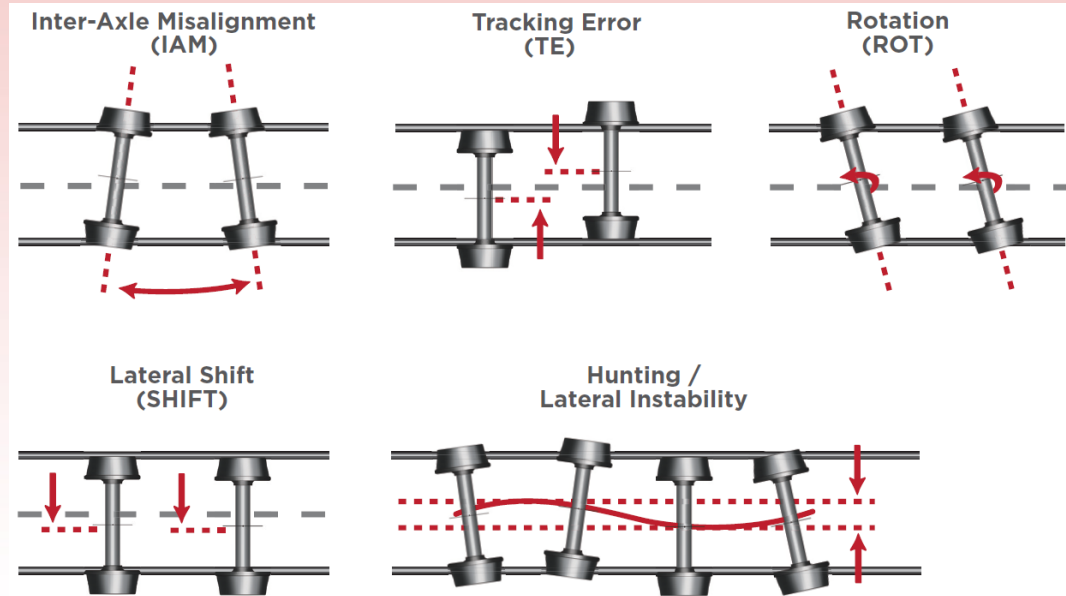
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# Wheel-Rail Interface Data

## Wheelset Based



## Truck Based





# Wheel-Rail Interface Data

**TBOGI-HD system collecting data since September 2009 since then:**

- 1. Unexpected patterns in the data at a population level**
- 2. How do patterns correlate with changes in rollingstock, track maintenance, wheel wear and rail wear?**
- 3. How did the inter-relationship between track degradation and rollingstock degradation manifest?**

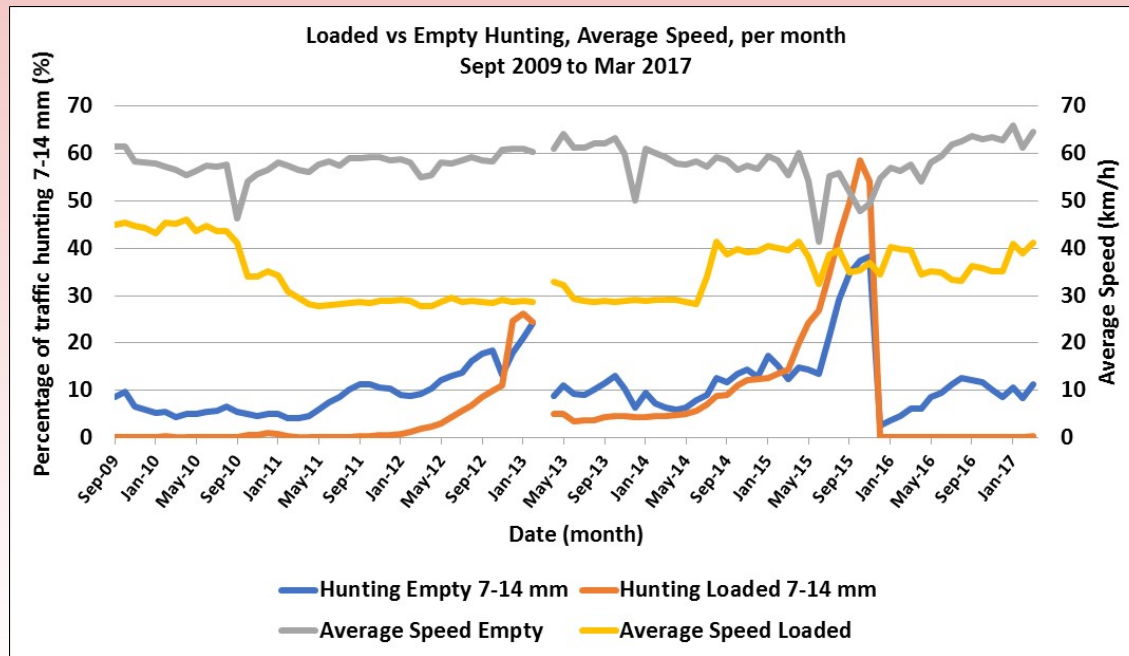


# Wheel-Rail Interface Data

## Trucks used at Vale EFC:

- Ride Control with frame brace (GDTs and GDUs)
- Ride Control without frame brace (GDTs)
- Ride Control with pads and without braces (GDTs and a small number of GDUs)
- Motion Control Barber, pads integrated with bearing adapters (GDU)
- S2E Barber with split wedges and pads (GDUs only)
- S2R Barber with pads (small number of GDTs)





Pre-2010 rail replaced with rail that had shorter life and was prone to vibration

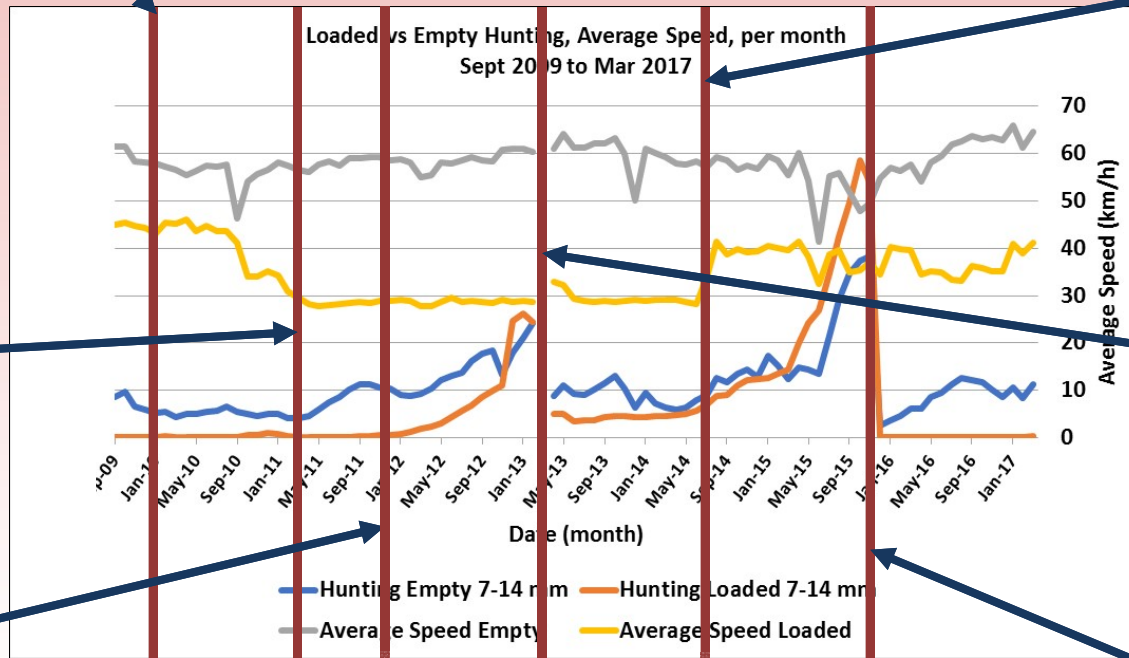
Manual track maintenance

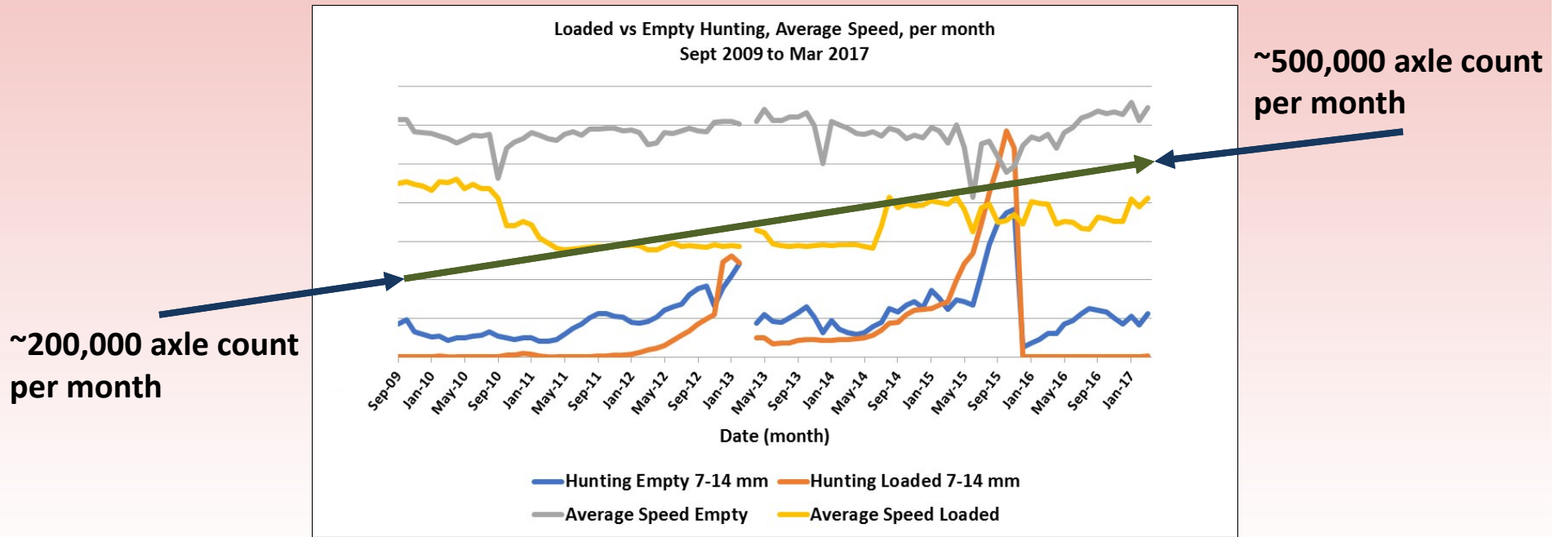
GDU bogies began entering the fleet

Rail replacement with better quality rail

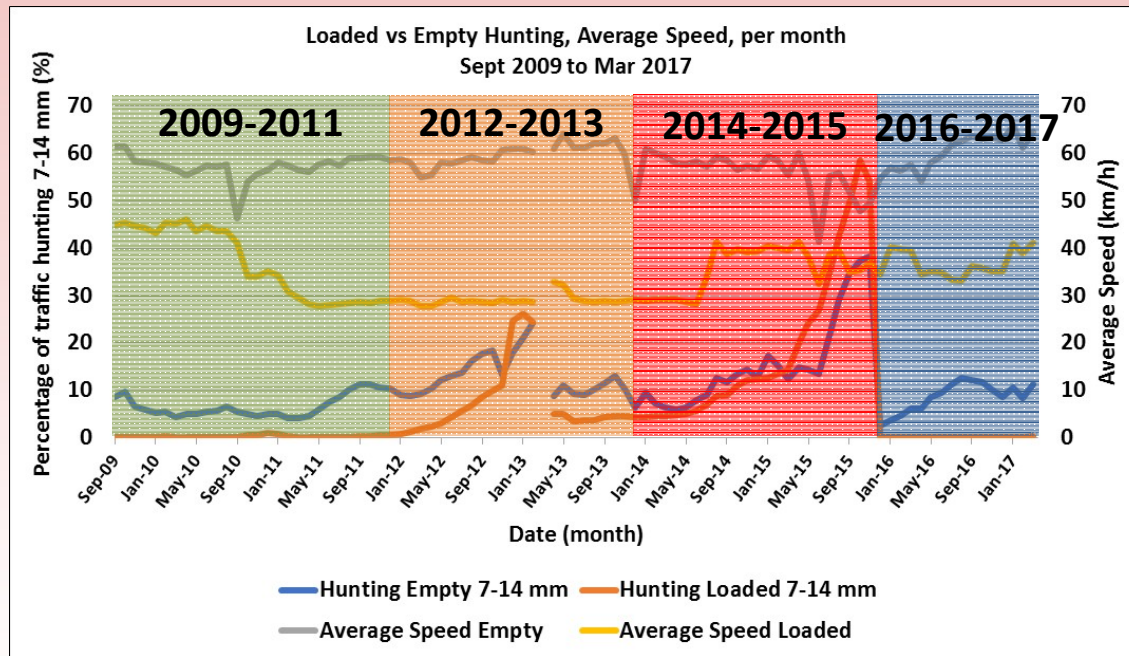
Manual track maintenance

Major rail replacement and ballast renewal + bogie maintenance









**2009 - 2011**

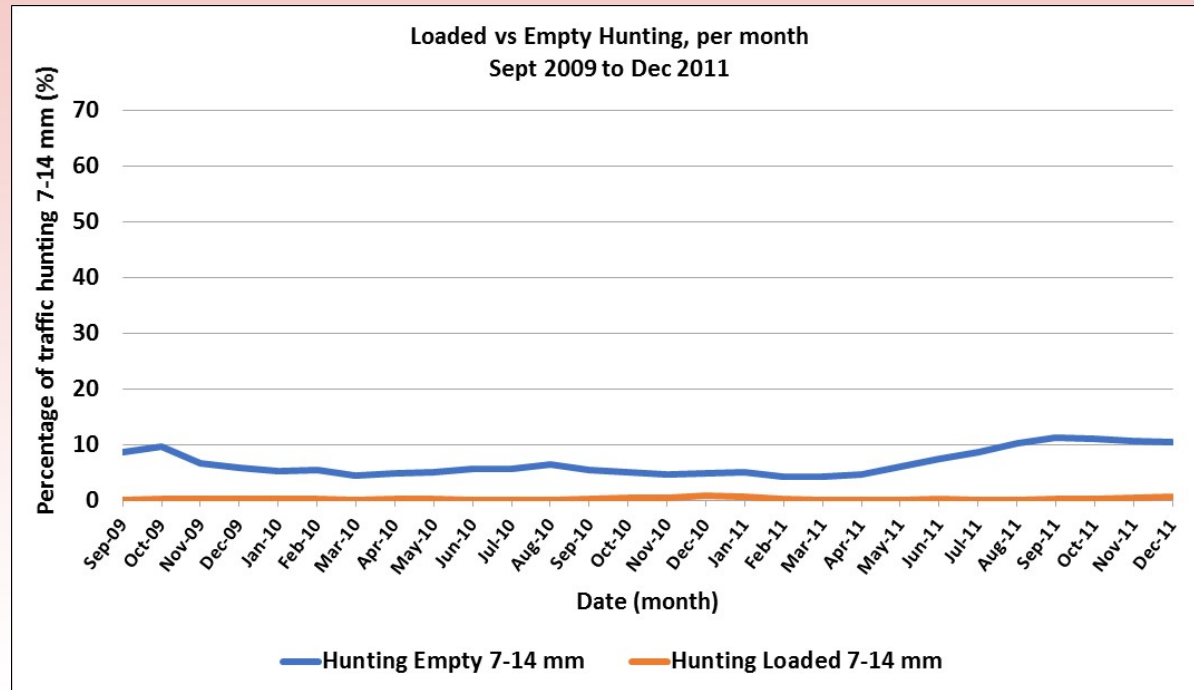


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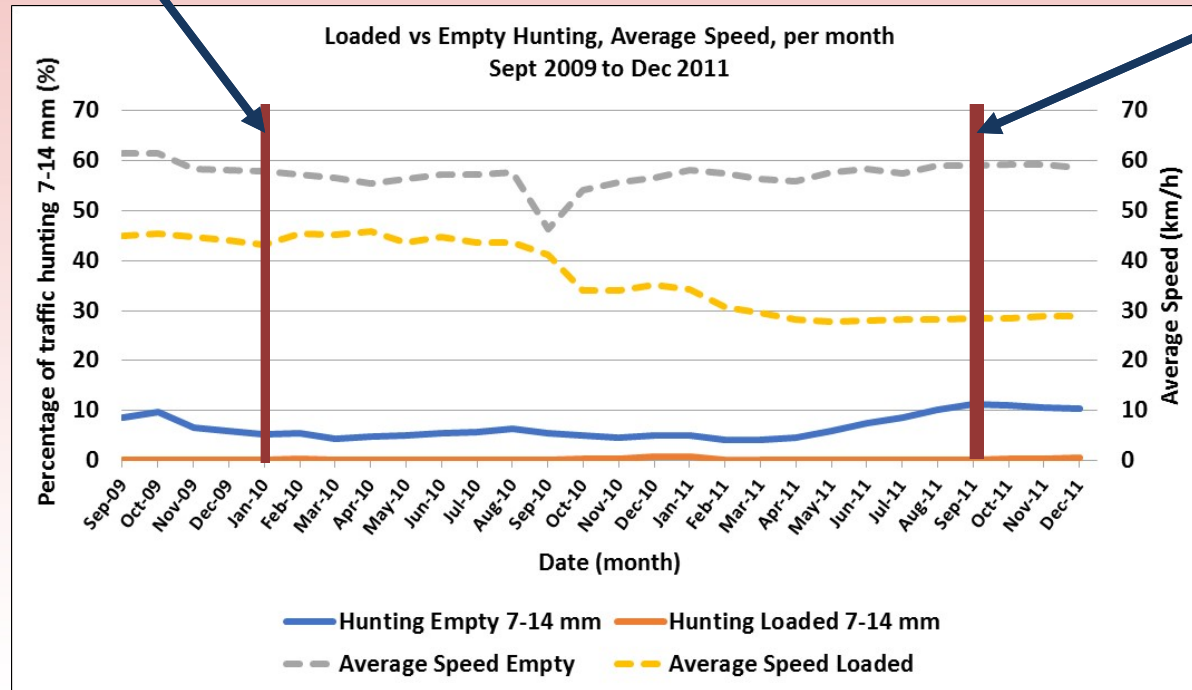
# 2009 - 2011



Pre-2010 rail replaced with rail that had shorter life and was prone to vibration

# 2009 - 2011

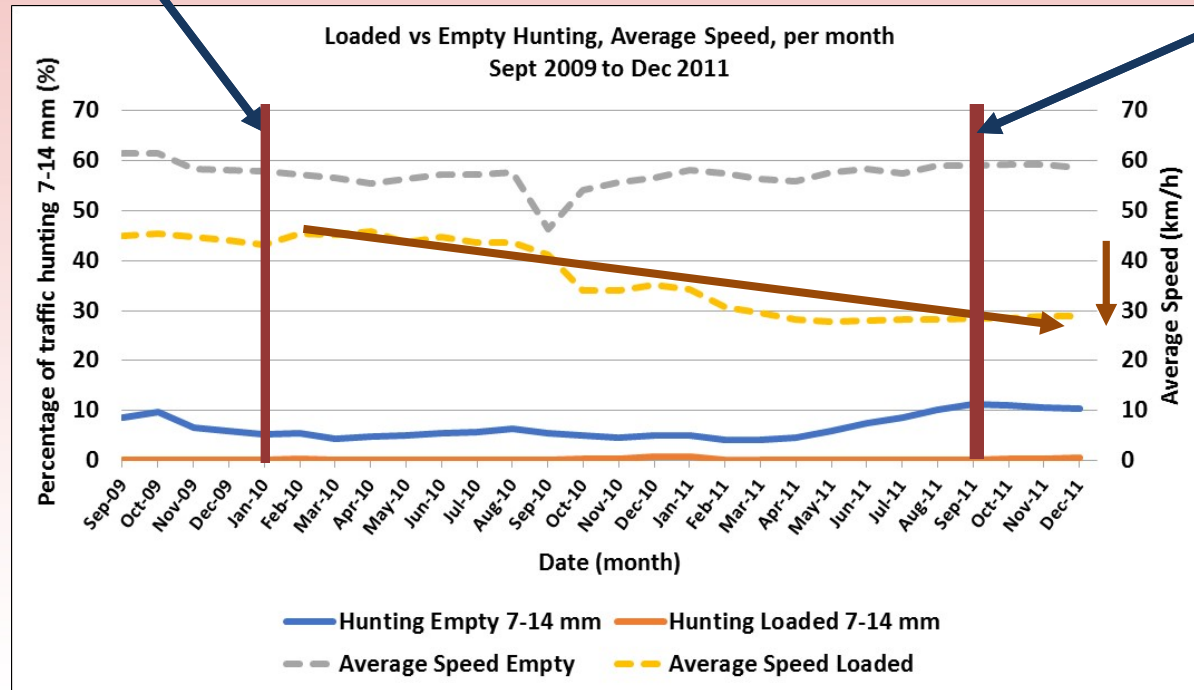
GDU bogies began entering the fleet



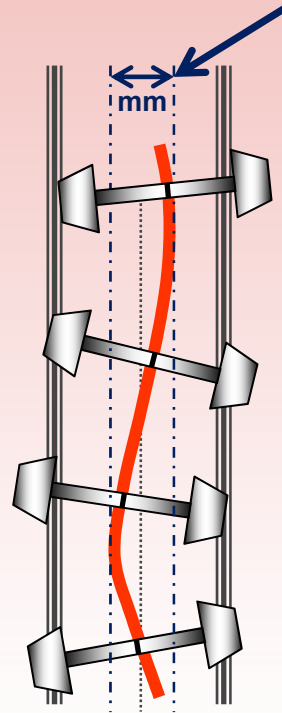
Pre-2010 rail replaced with rail that had shorter life and was prone to vibration

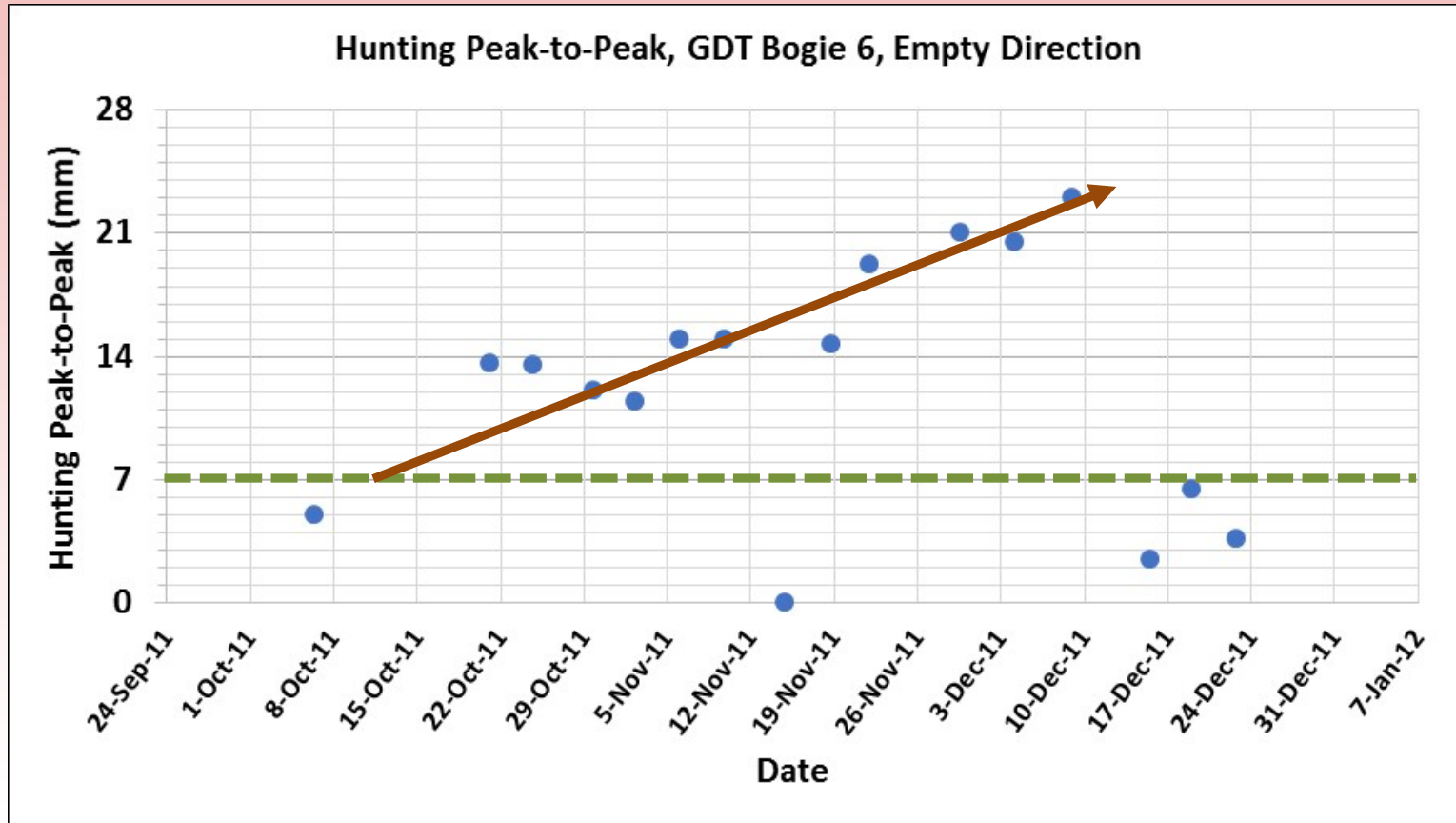
# 2009 - 2011

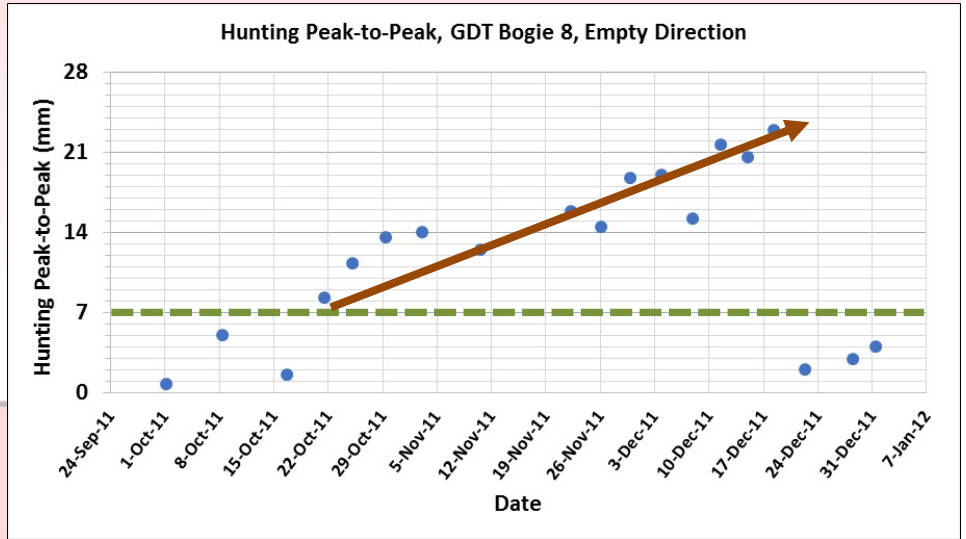
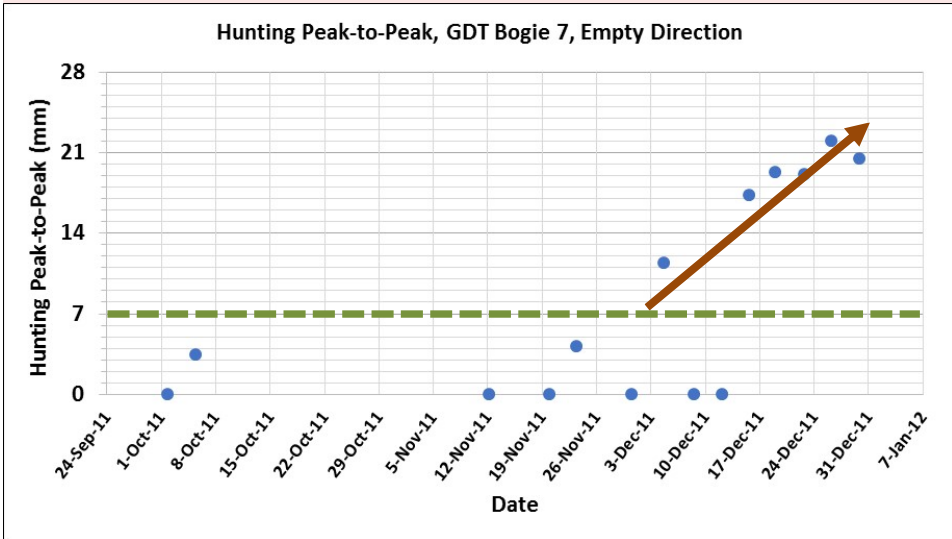
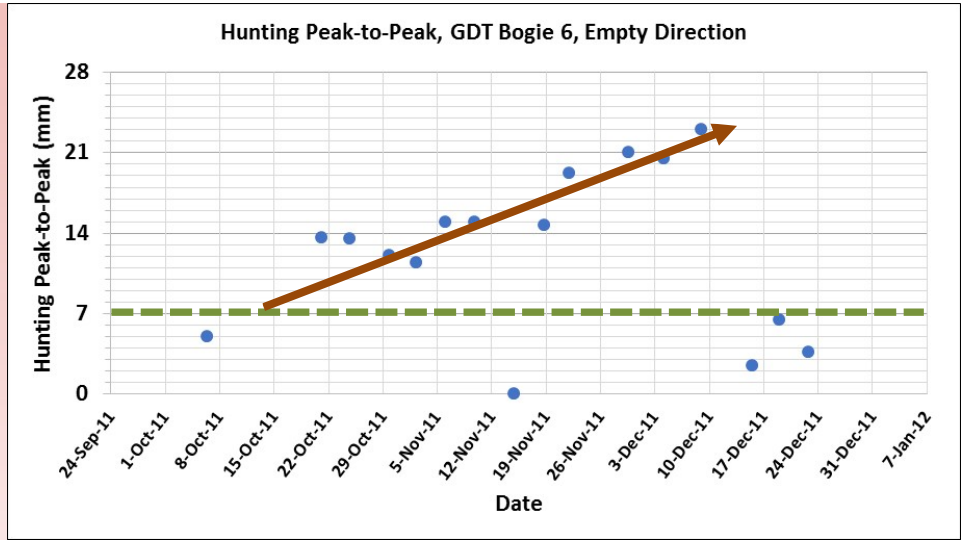
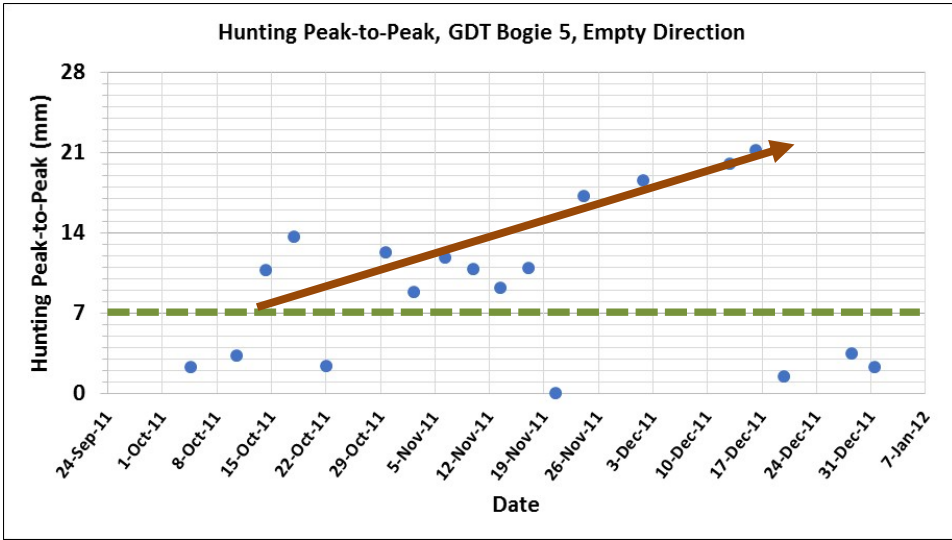
GDU bogies began entering the fleet



Peak-to-Peak









# Observations: 2009-2011

1. Average degradation rate for hunting defects was 14 months
2. Degradation trends typically not steep, were manageable by rolling stock maintenance
3. There were still some steep trends - degradation within 1 month - that required quicker intervention
4. Hunting degradation predominantly manifesting when cars empty, which is normal for heavy-haul



# 2012 - 2013

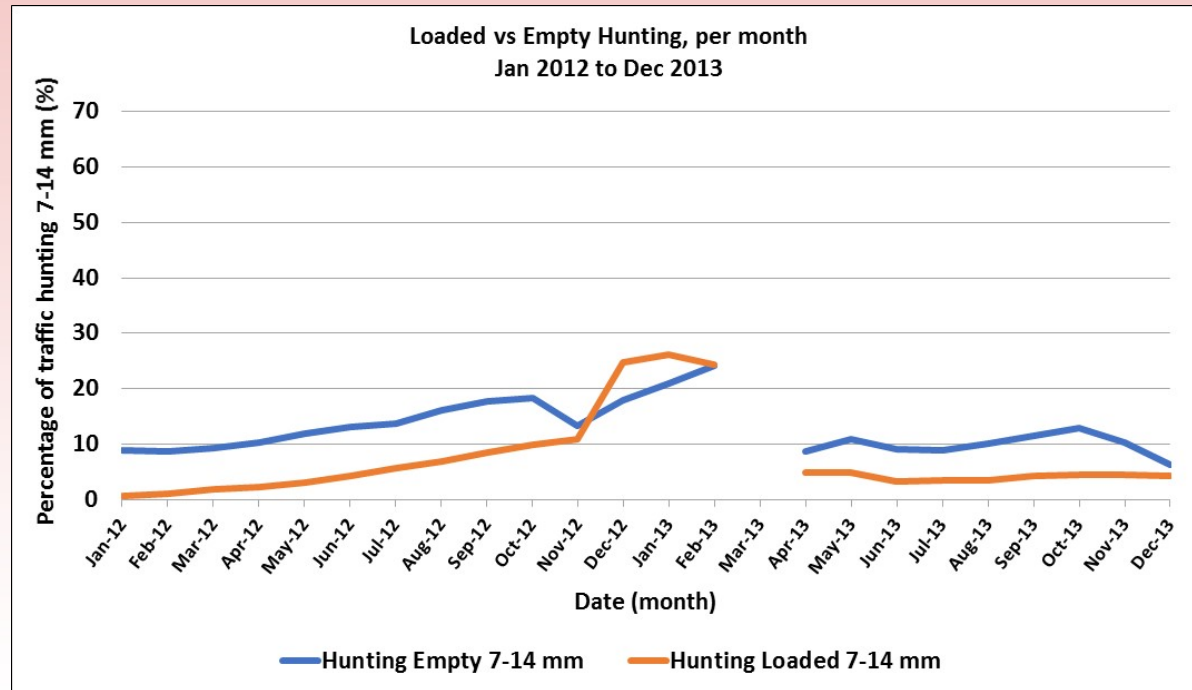


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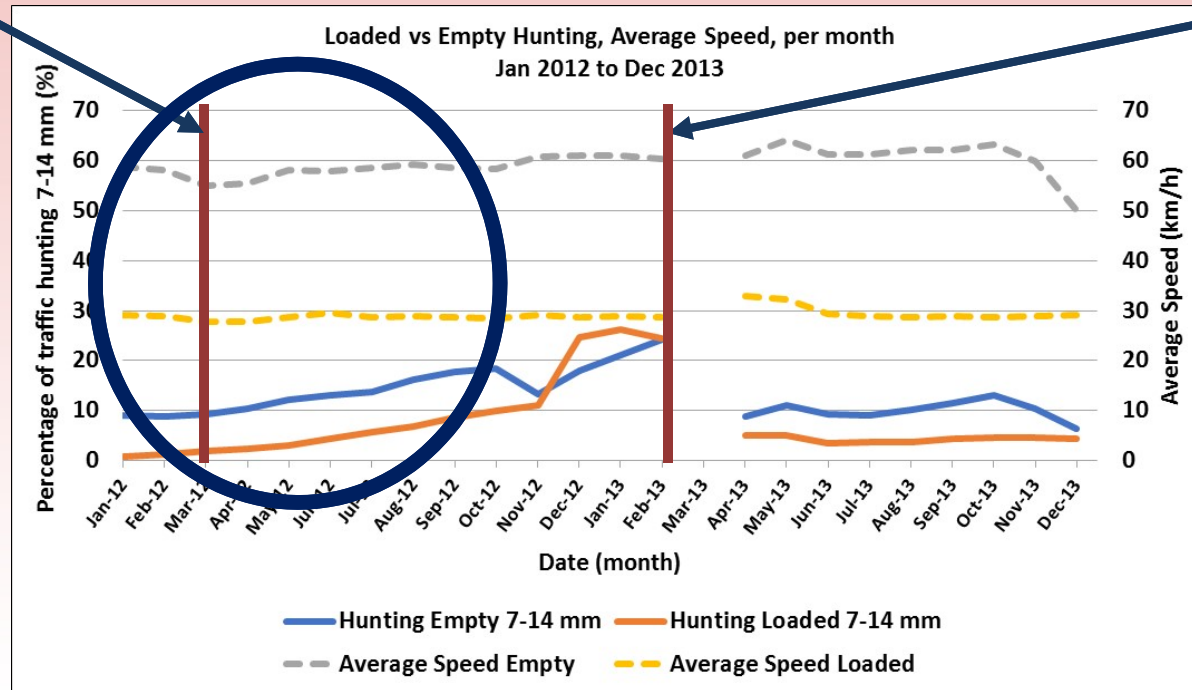
# 2012 - 2013



Manual grinding/tamping,  
and sleeper leveling

# 2012 - 2013

Replaced previous rail (25m sections)  
with better quality rail in longer lengths (250m sections)



# March 2012



**Fixation Renewal**



**Manual Grinding**



**Sleeper Leveling**

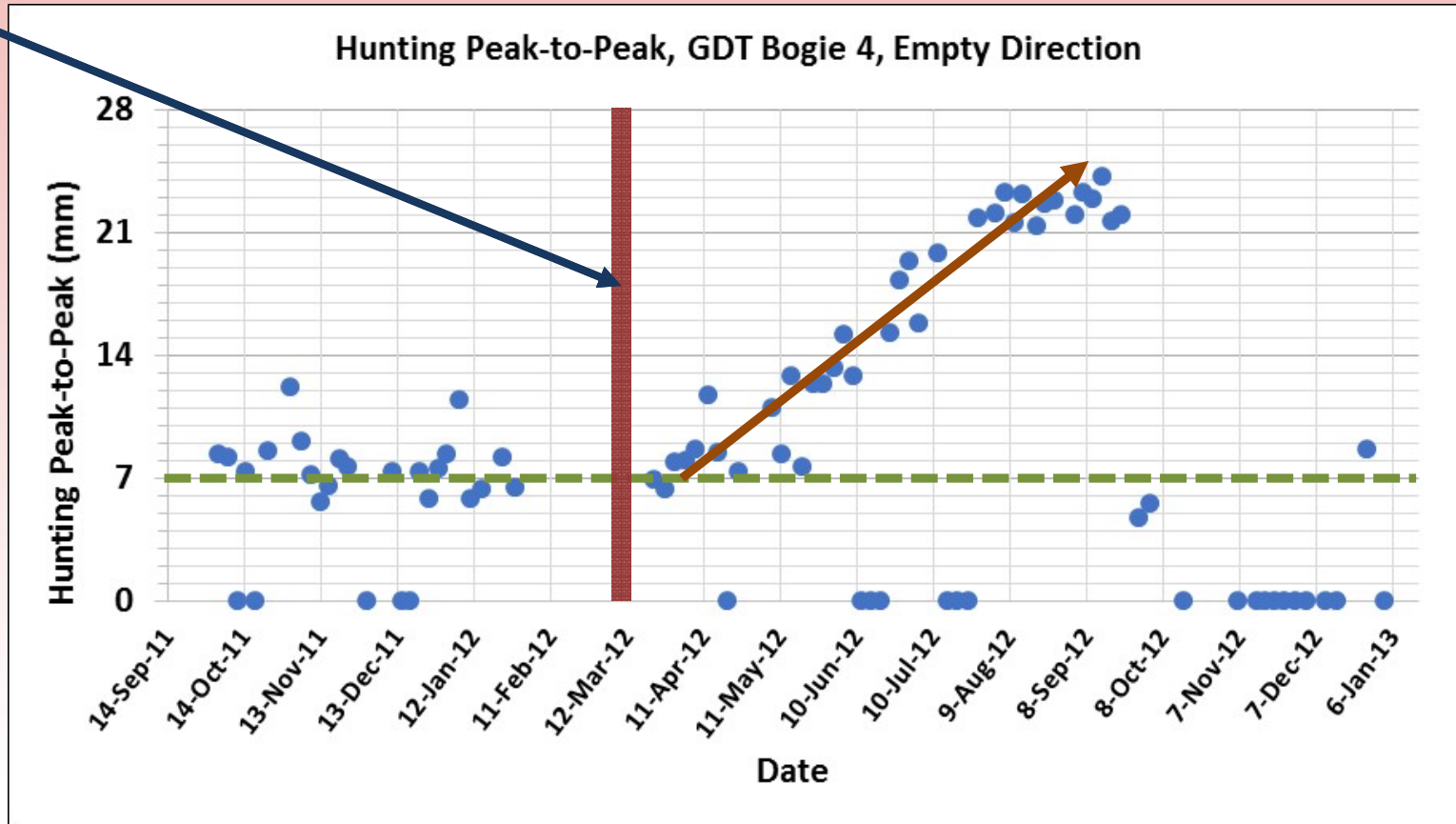
**1<sup>st</sup> Intervention  
Manual Maintenance**



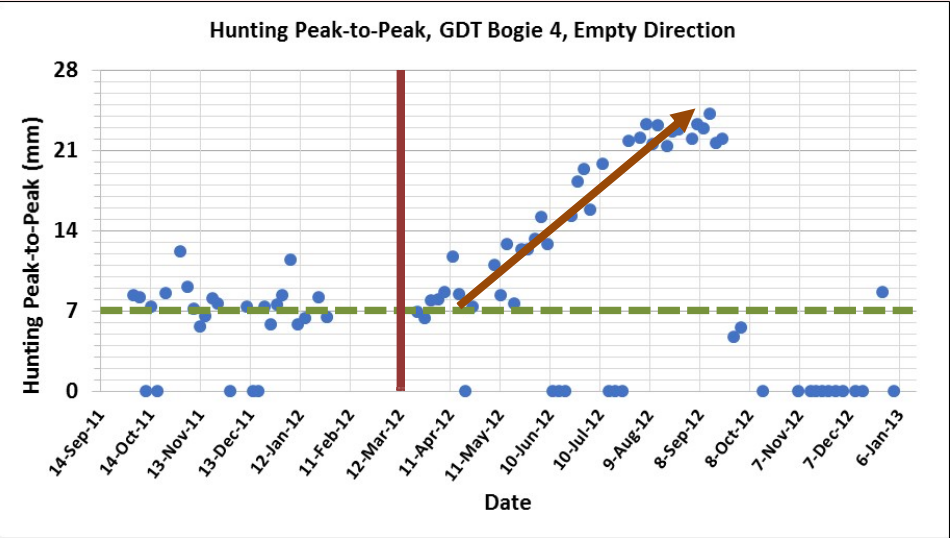
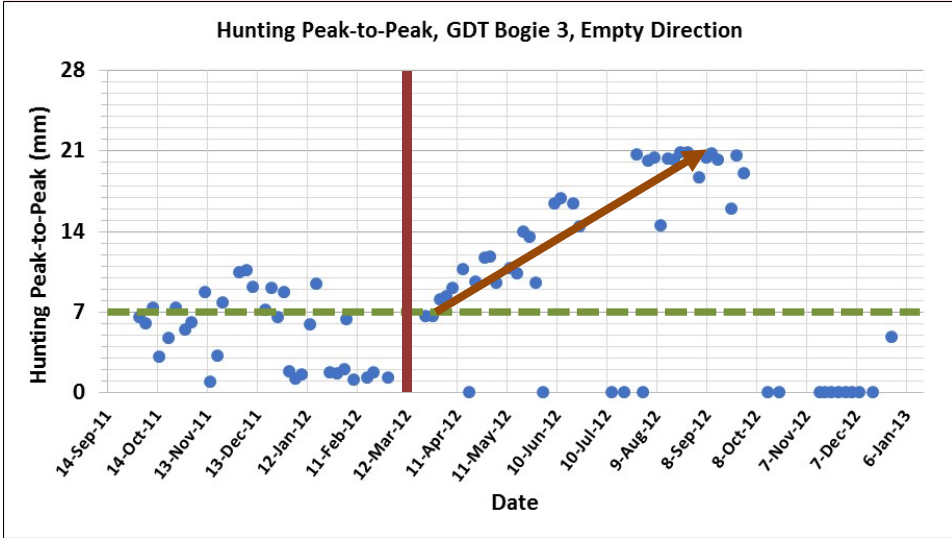
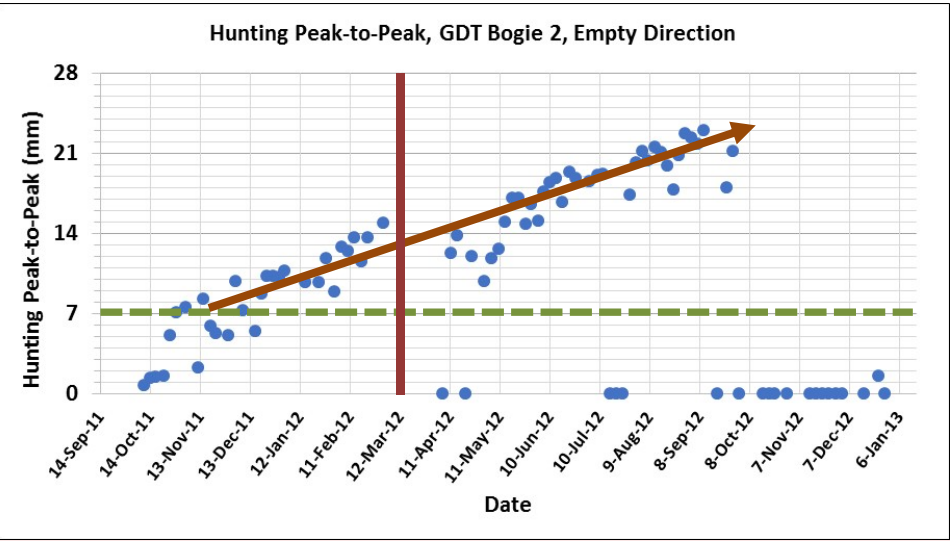
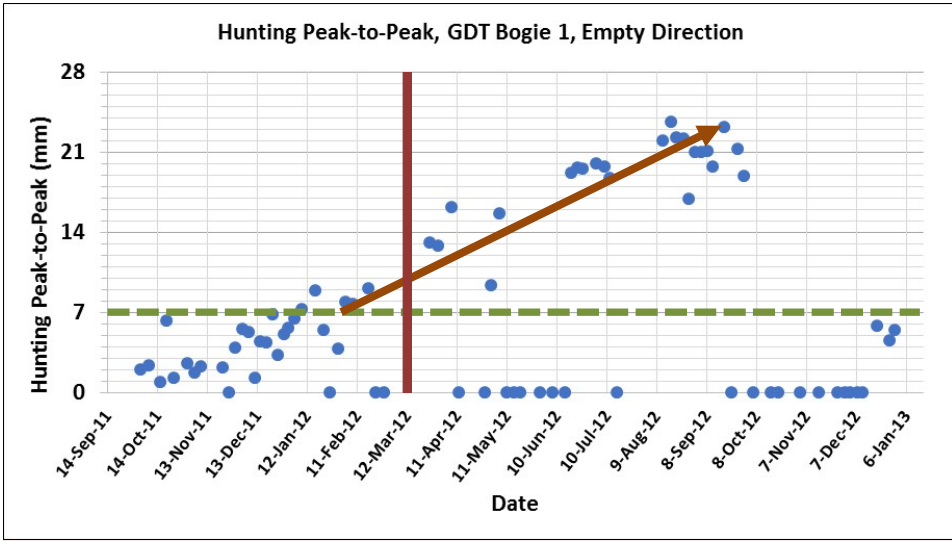
**Manual Tamping**



# Manual track maintenance



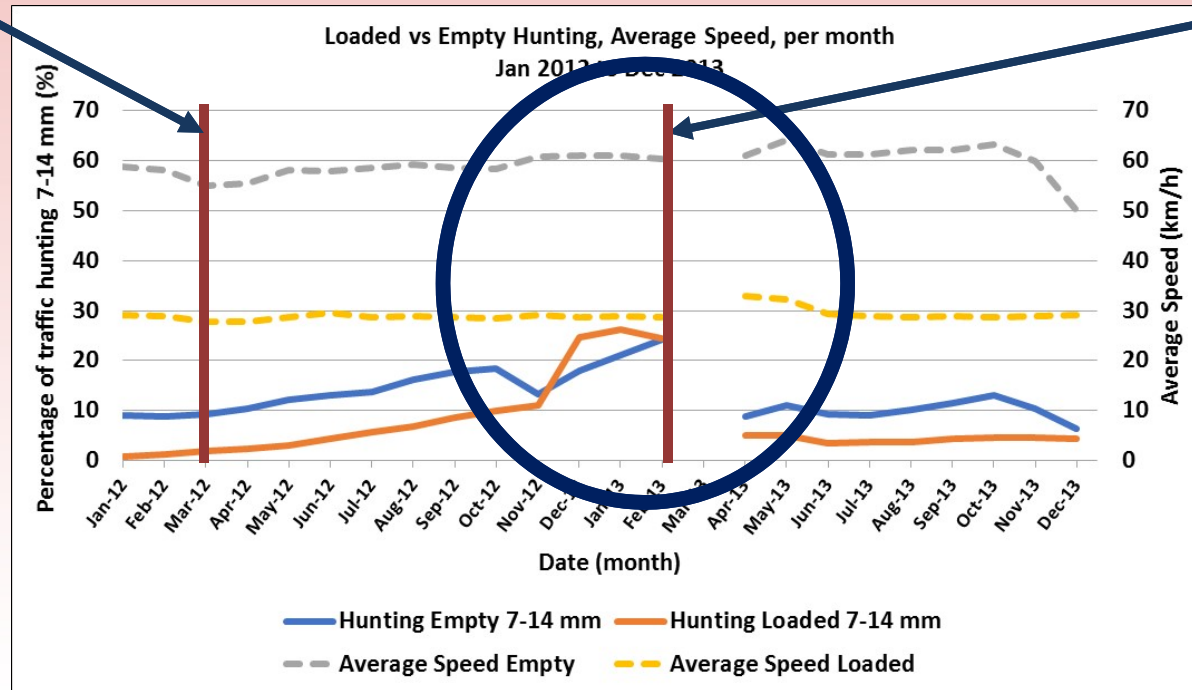




Manual grinding/tamping,  
and sleeper leveling

# 2012 - 2013

Replaced previous rail (25m sections) with better quality rail (250m sections)

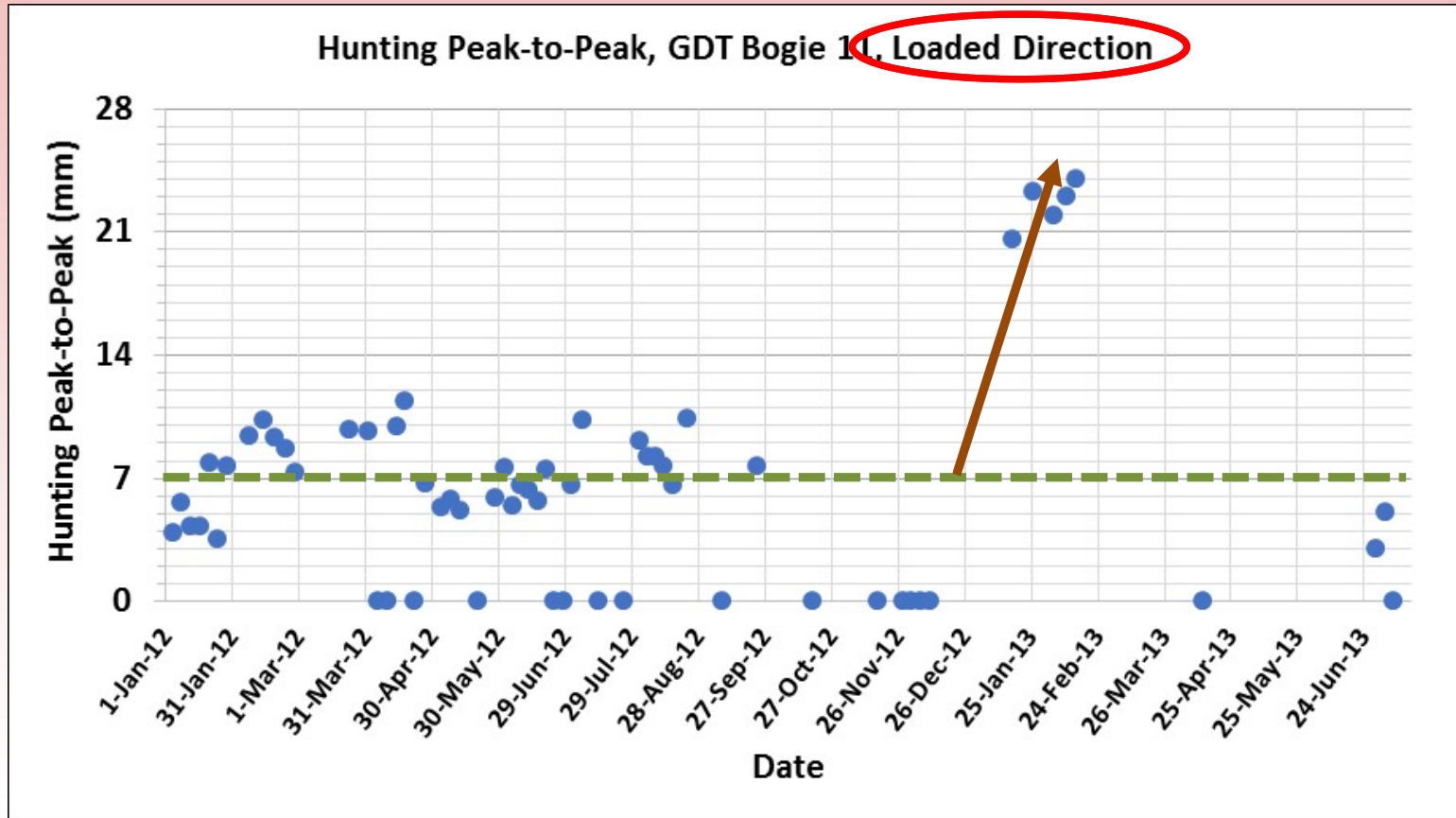




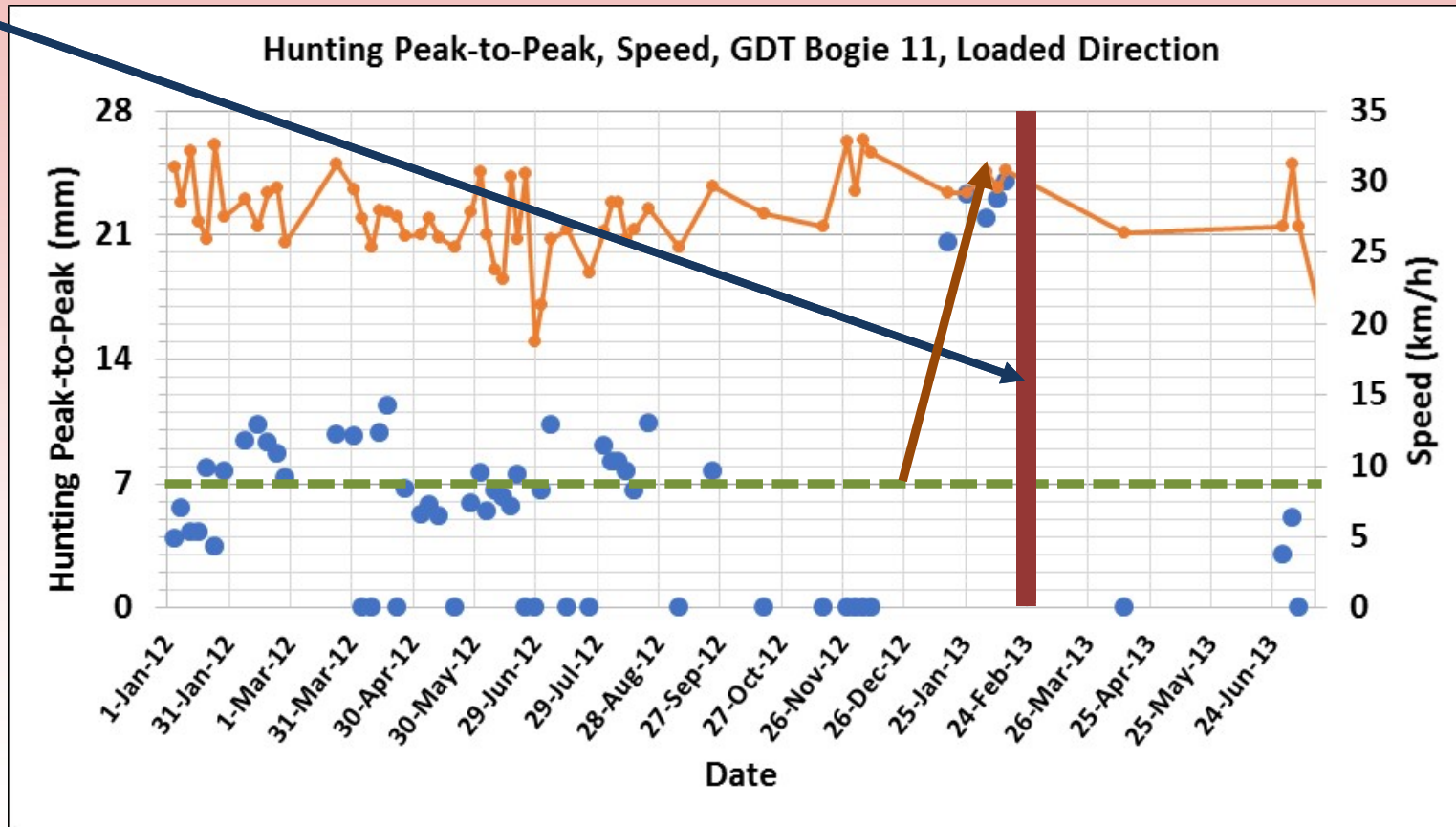
# March 2013

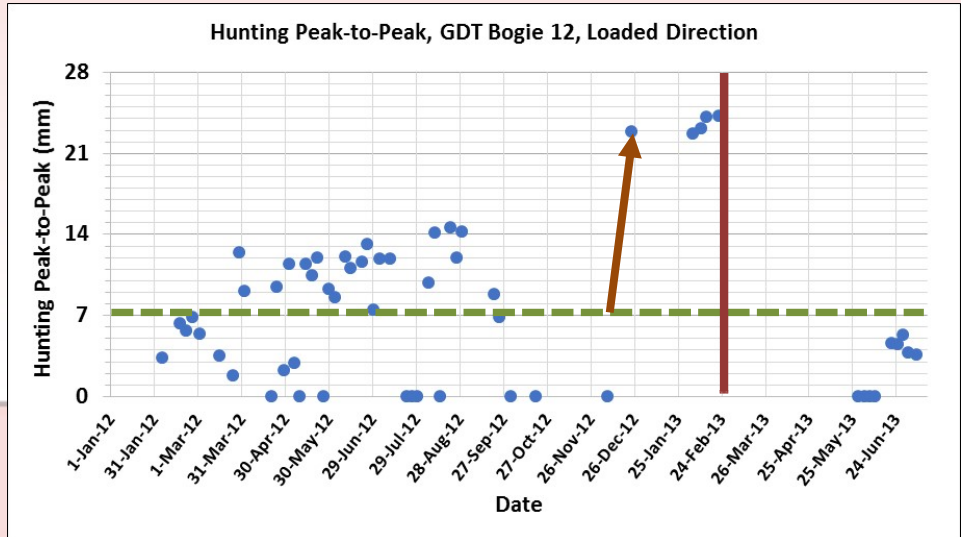
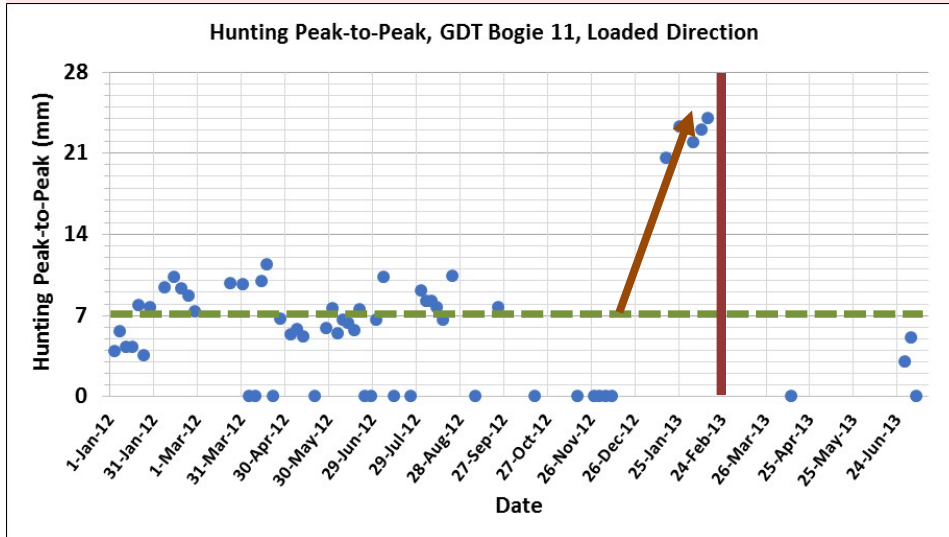
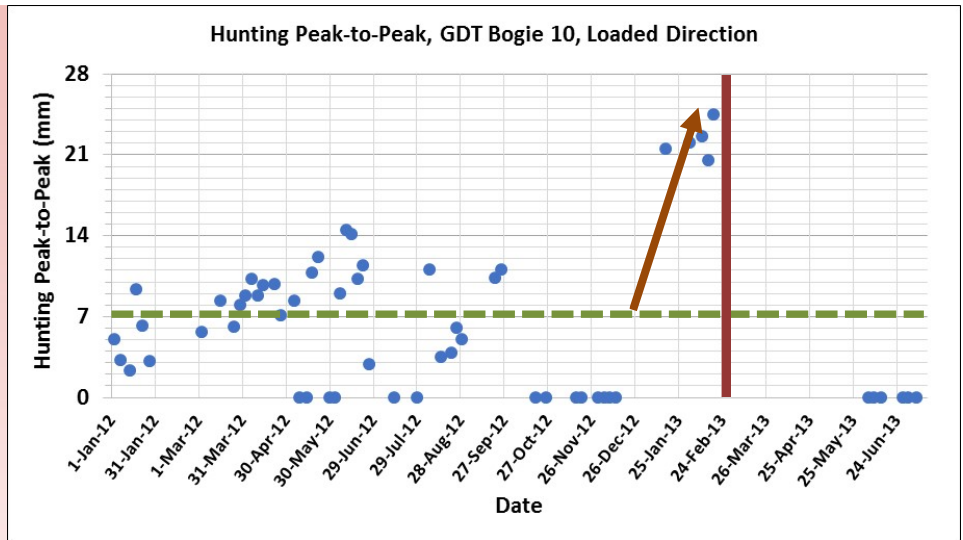
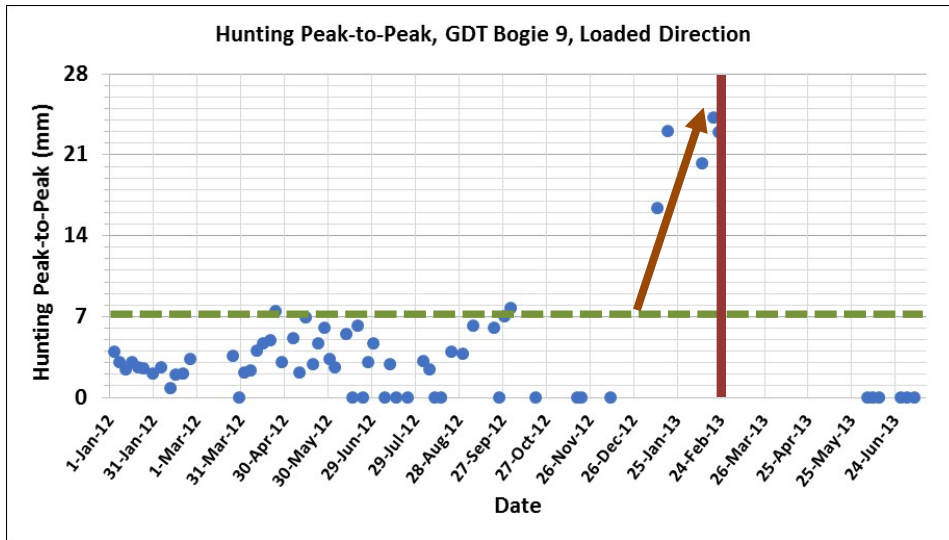
## 2<sup>nd</sup> Intervention Rail Replacement





# Rail replacement with better quality rail





# Observations: 2012-2013

1. Predominantly GDT bogies that experienced repeat hunting
2. Degradation time for gradual-onset defects reduced from average of 14 months to average of 7 months
3. Bogies that experienced sudden-onset loaded hunting were different bogies to those that experienced gradual-onset empty hunting
4. Sudden-onset and gradual-onset hunting defects continued degrading without significant changes in speed (per bogie)



# 2014 - 2015



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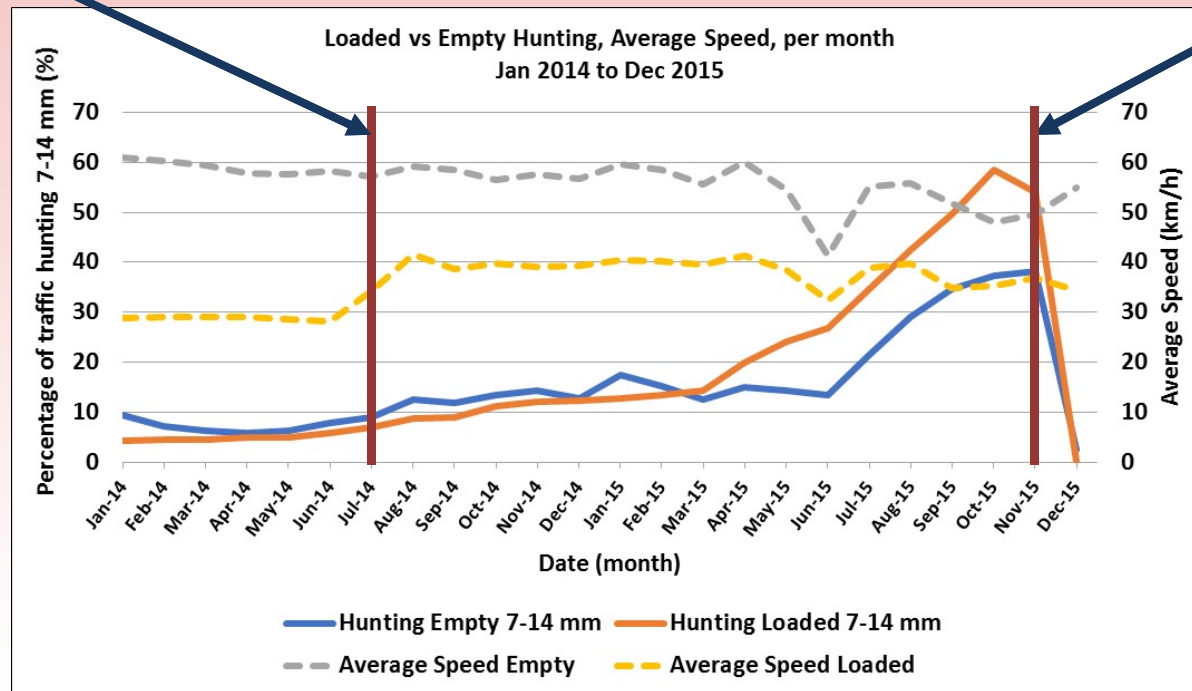
**WRI 2017**



Manual grinding/tamping,  
and sleeper leveling

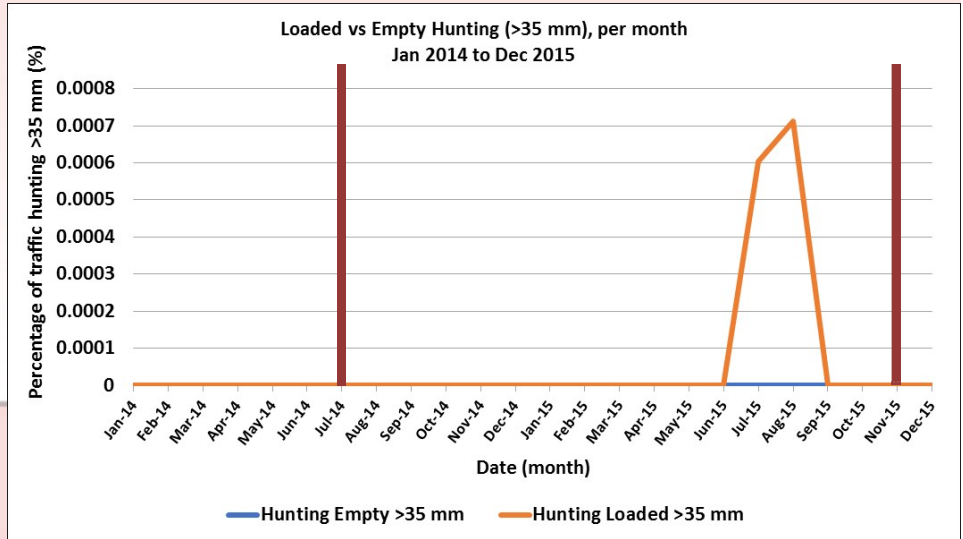
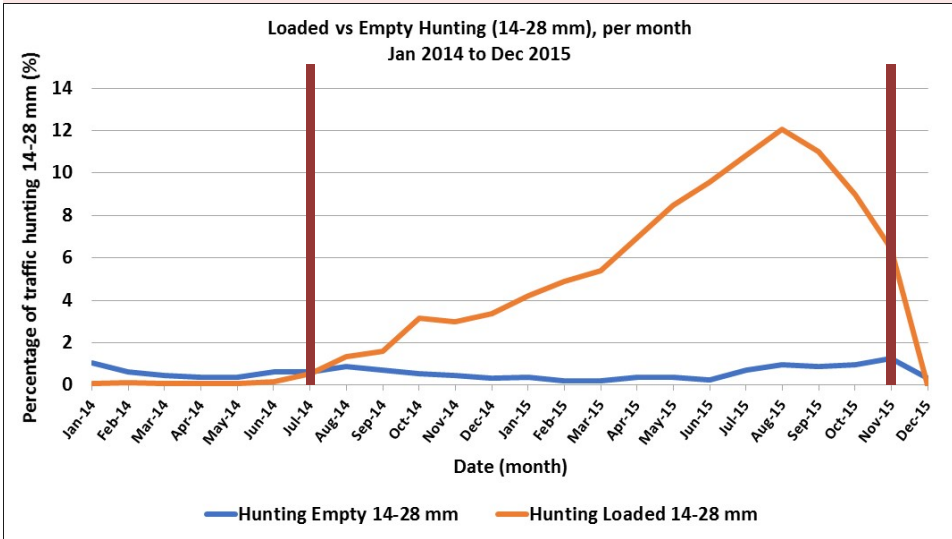
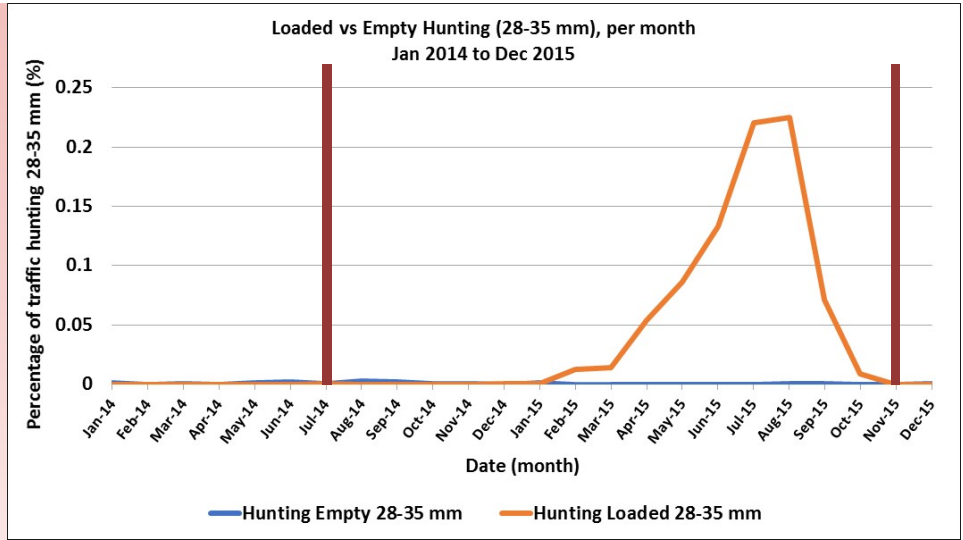
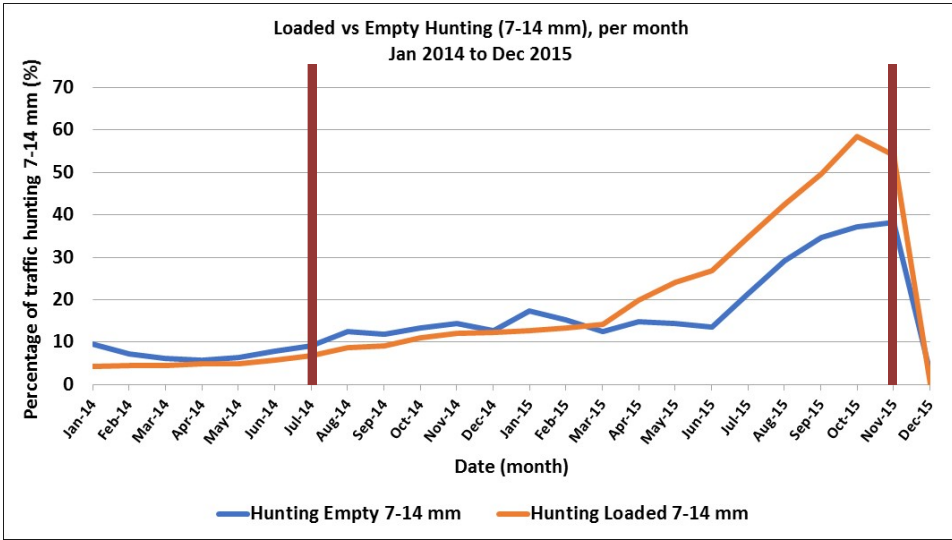
# 2014 - 2015

Major track overhaul:  
Replaced rail, ballast  
cleaning/renewal,  
mechanical tamping  
and leveling



Plus a bogie  
maintenance  
regime focused  
on the extreme  
defects







# Observations: 2014-2015

1. Still predominantly GDT bogies experiencing repeat hunting
2. Vale noticed frame braces starting to break in 2014, and significant increase in twisted/broken frame braces in 2015. Also marked increase in asymmetrical wear in wheelsets.
3. Hunting bogies divided into three main types:
  - a) Gradual-onset defects when empty
  - b) Gradual-onset defects when loaded
  - c) Sudden-onset defects when loaded

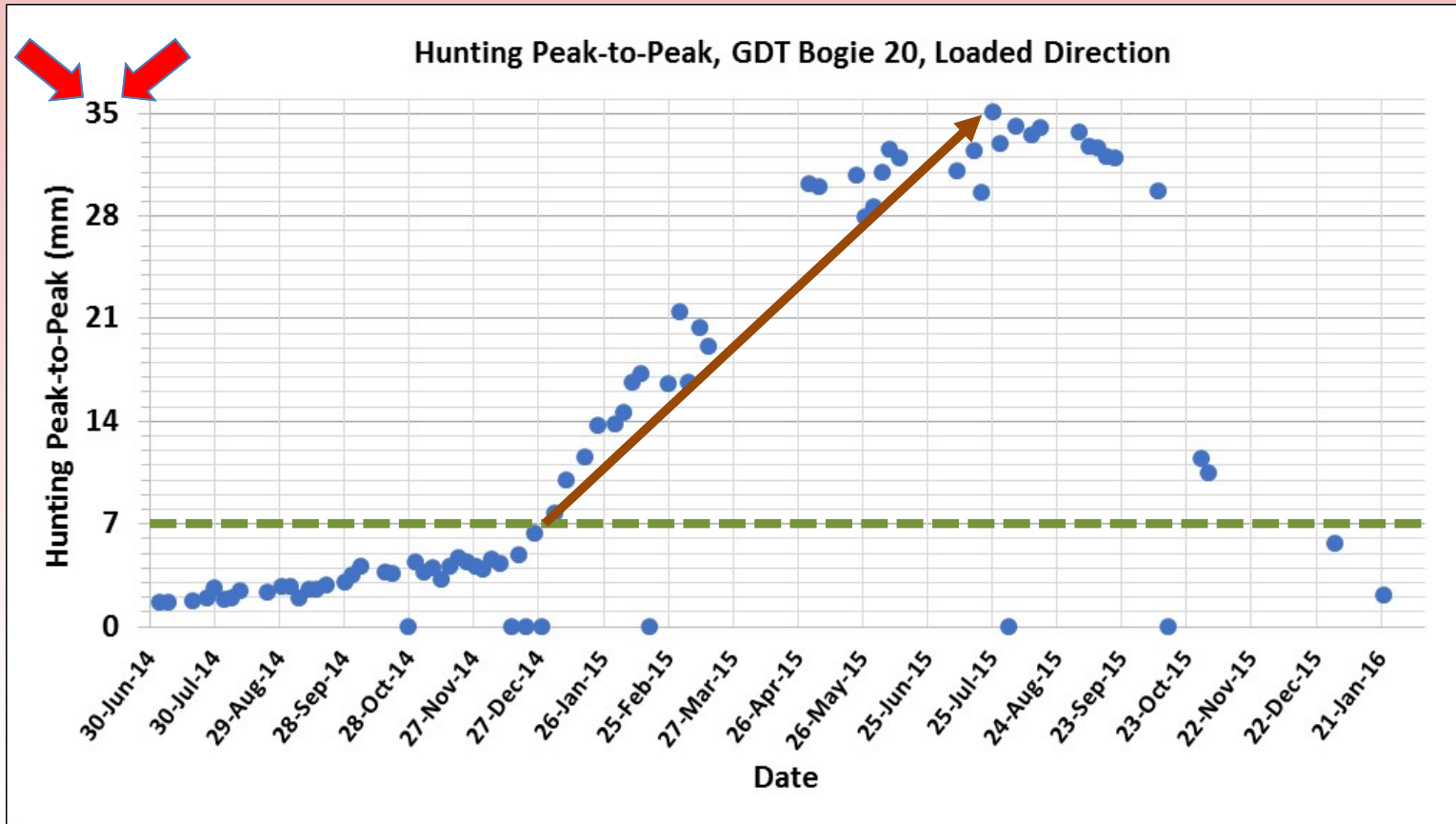


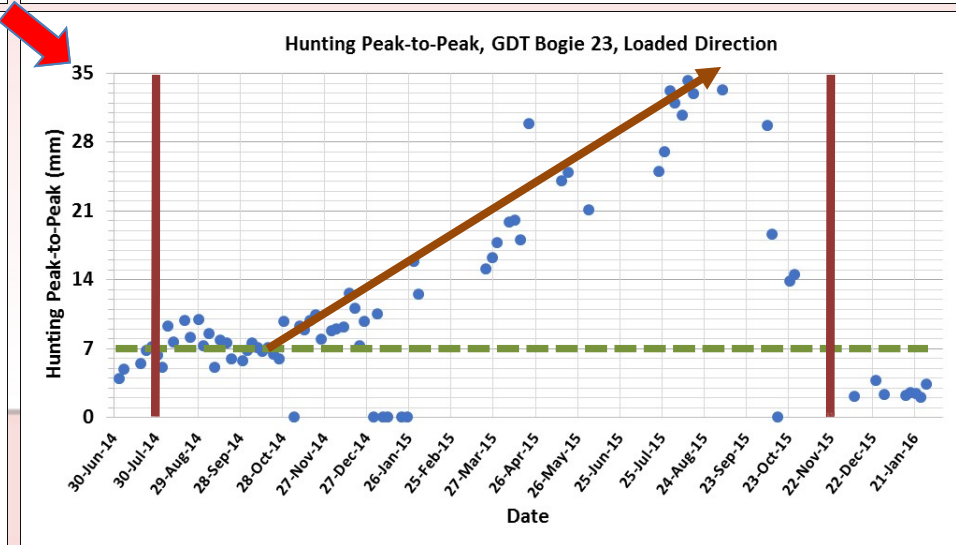
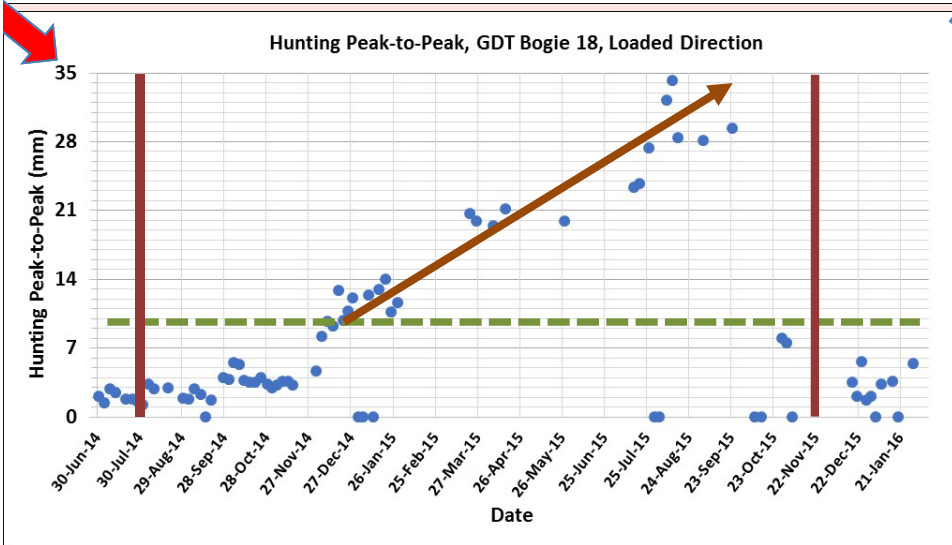
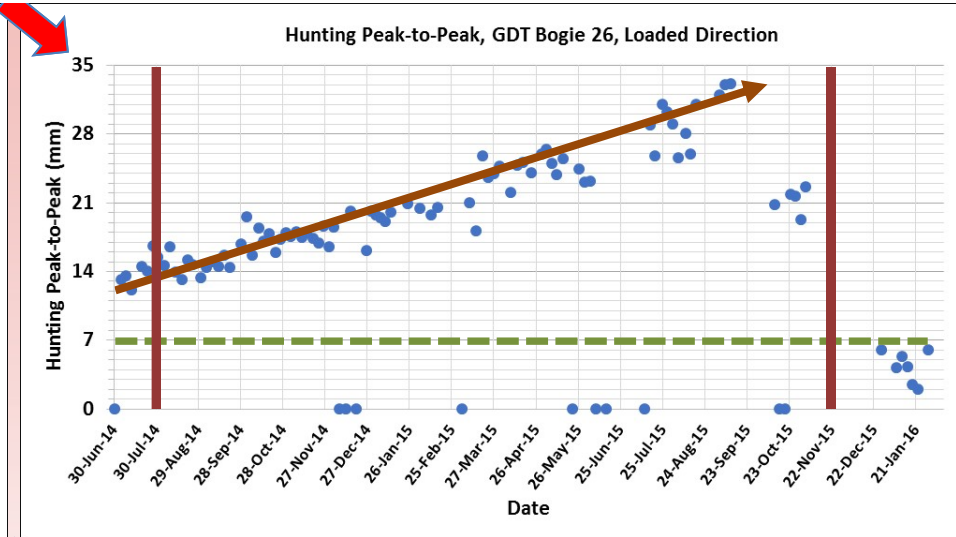
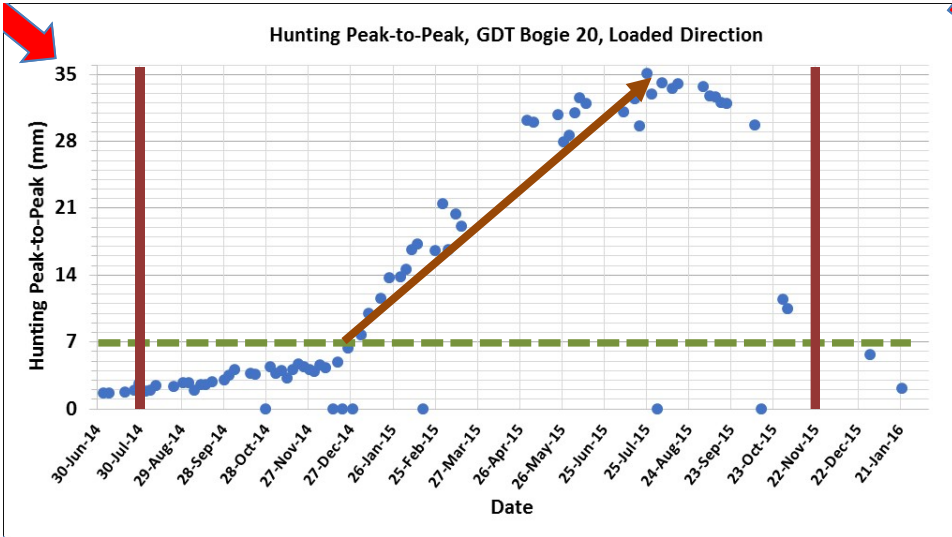
**Type (a): Gradual-onset defects when empty**  
**Continued developing much as before, but increased rate of incidence**



## Type (b): Gradual-onset defects when loaded

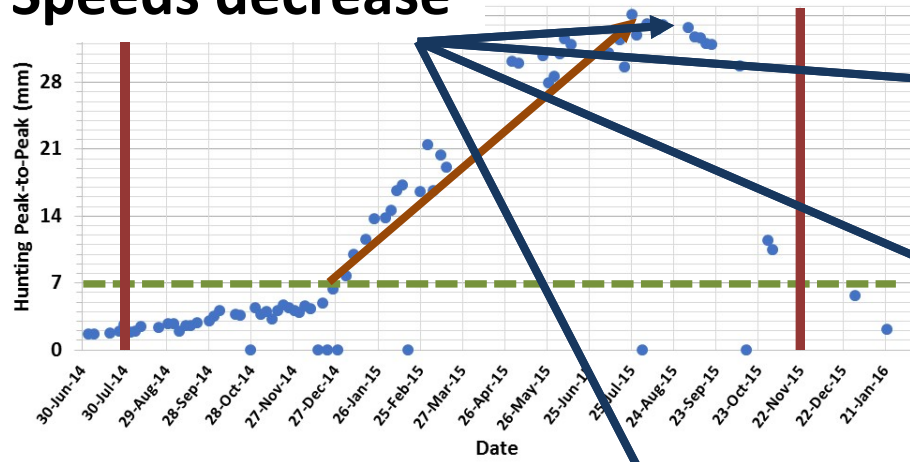




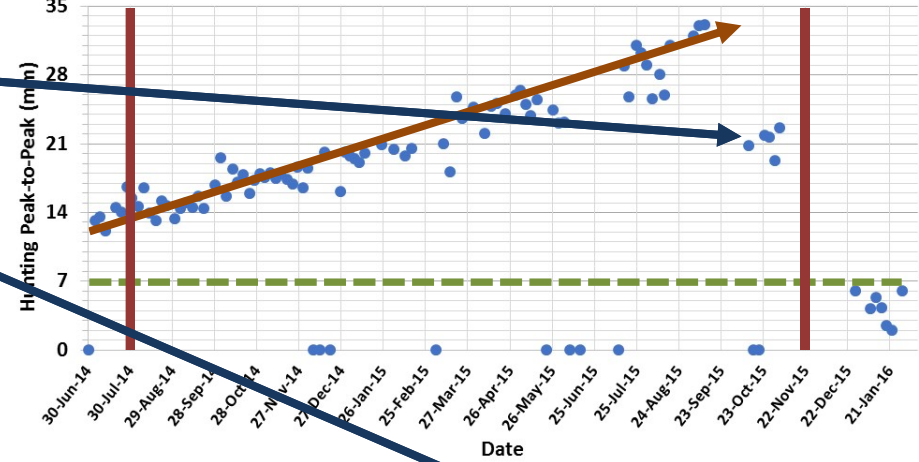


# Speeds decrease

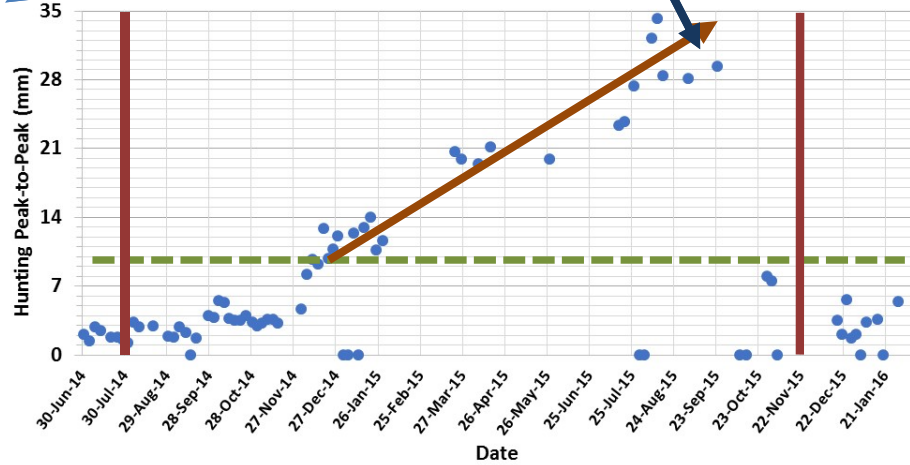
IT Bogie 20, Loaded Direction



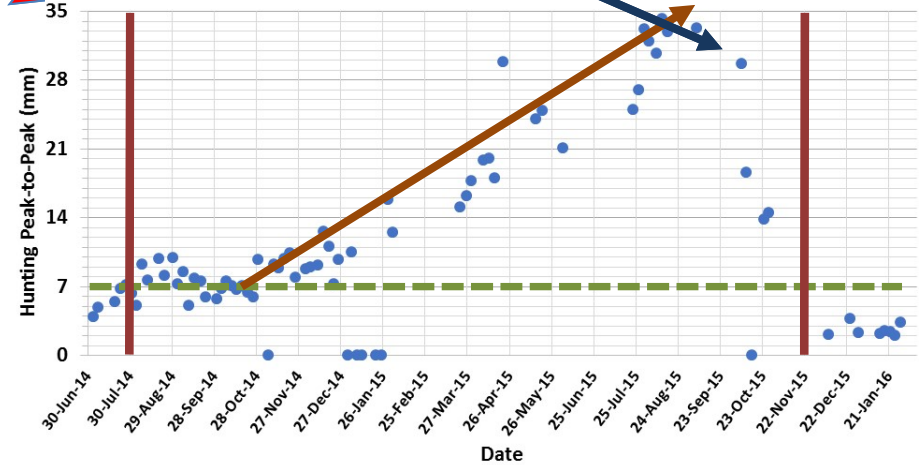
Hunting Peak-to-Peak, GDT Bogie 26, Loaded Direction



Hunting Peak-to-Peak, GDT Bogie 18, Loaded Direction

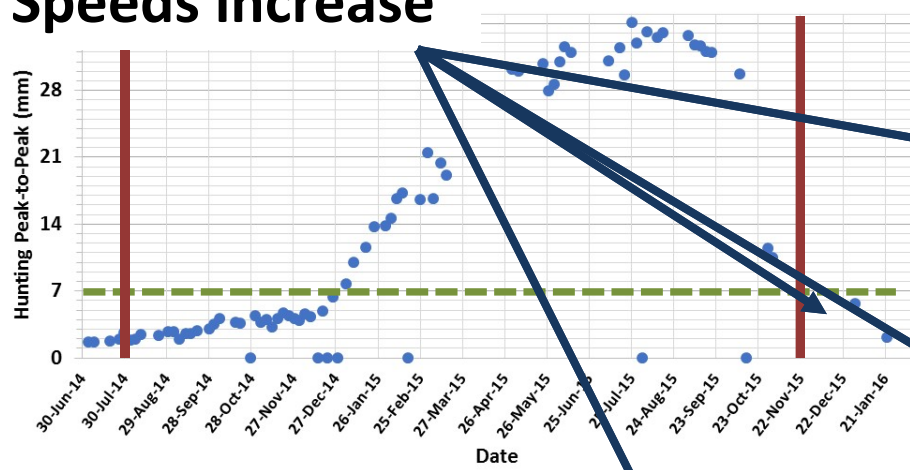


Hunting Peak-to-Peak, GDT Bogie 23, Loaded Direction

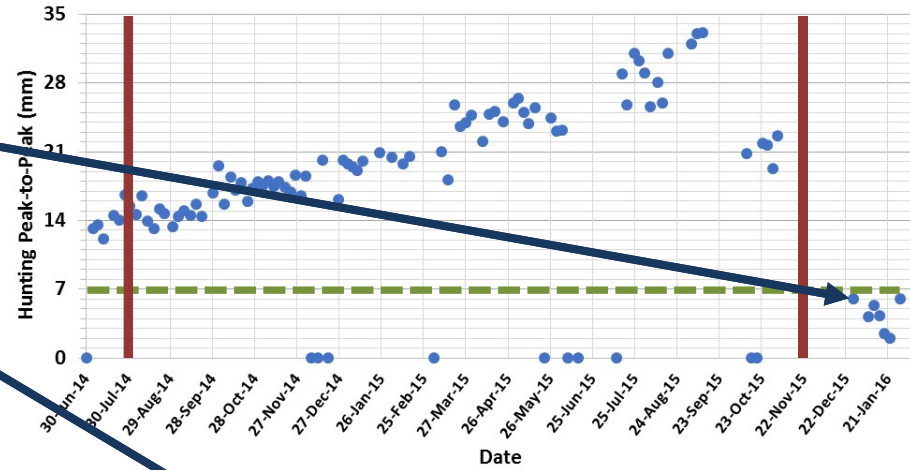


# Speeds increase

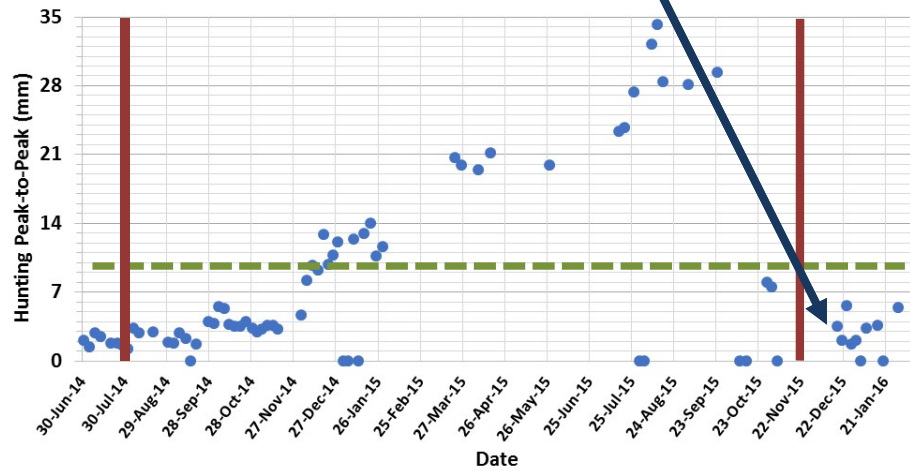
JT Bogie 20, Loaded Direction



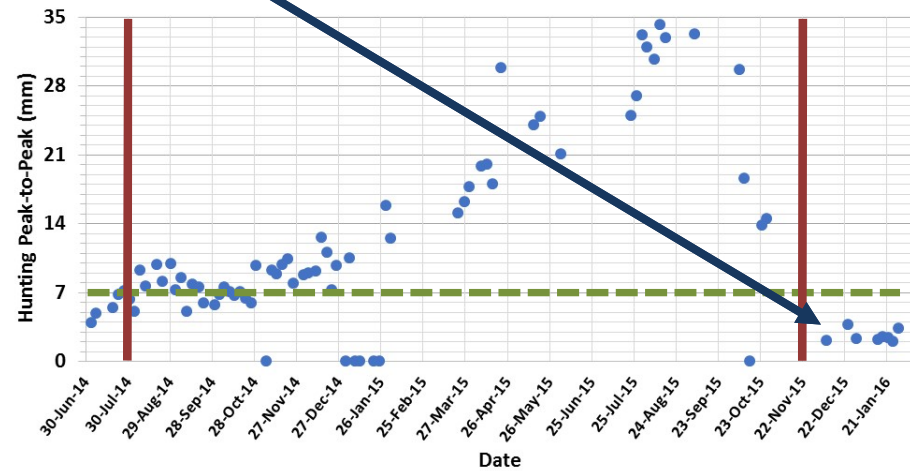
Hunting Peak-to-Peak, GDT Bogie 26, Loaded Direction



Hunting Peak-to-Peak, GDT Bogie 18, Loaded Direction



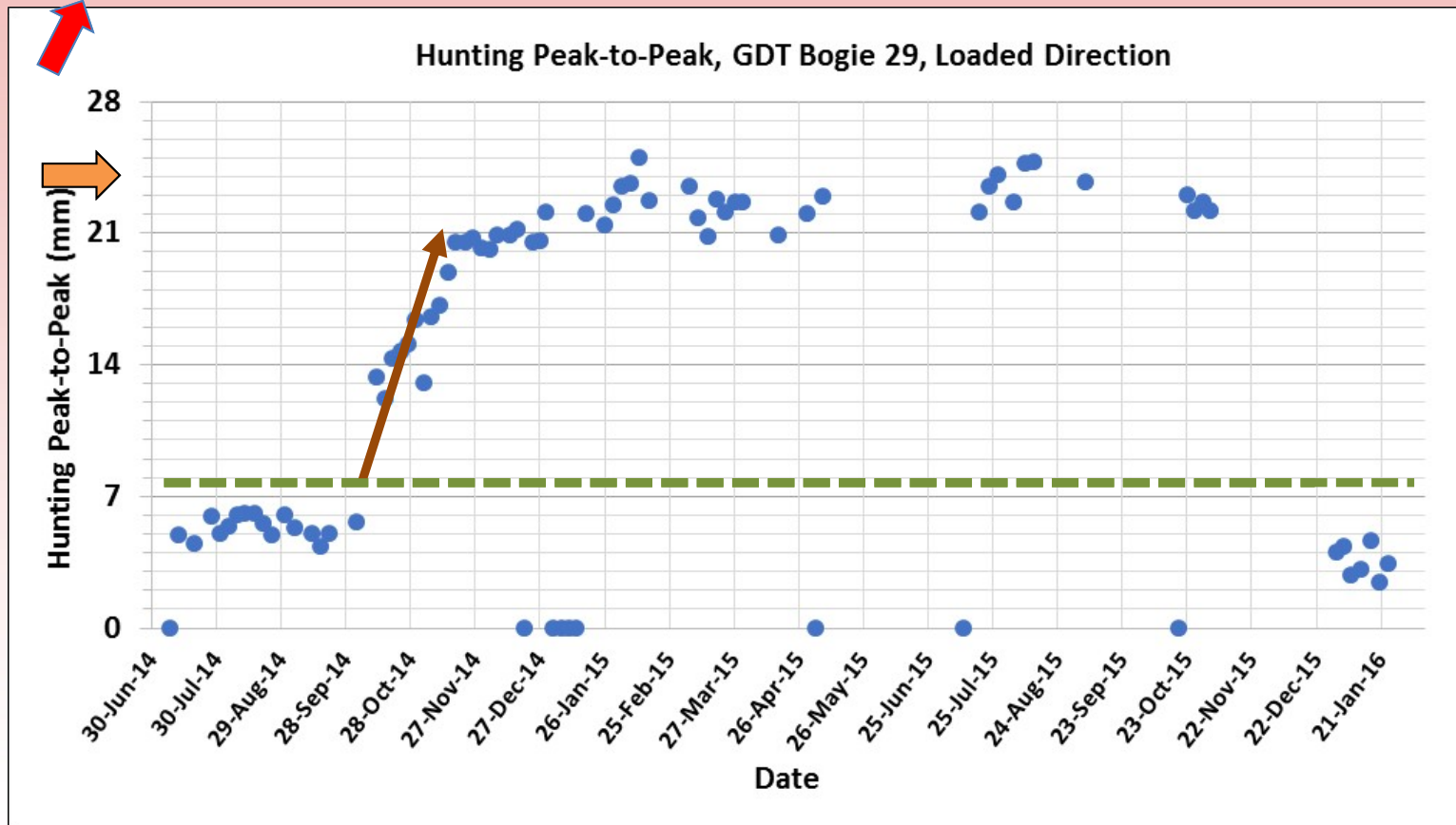
Hunting Peak-to-Peak, GDT Bogie 23, Loaded Direction

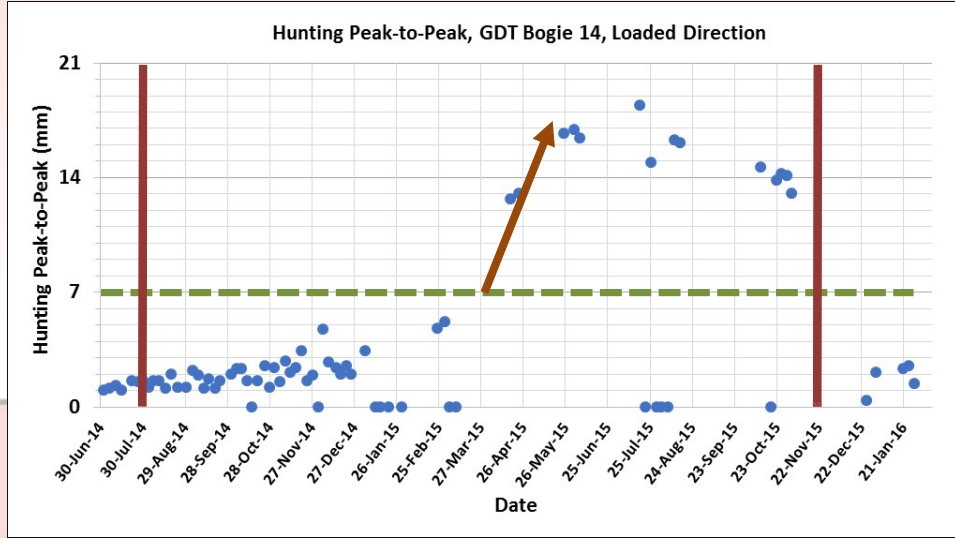
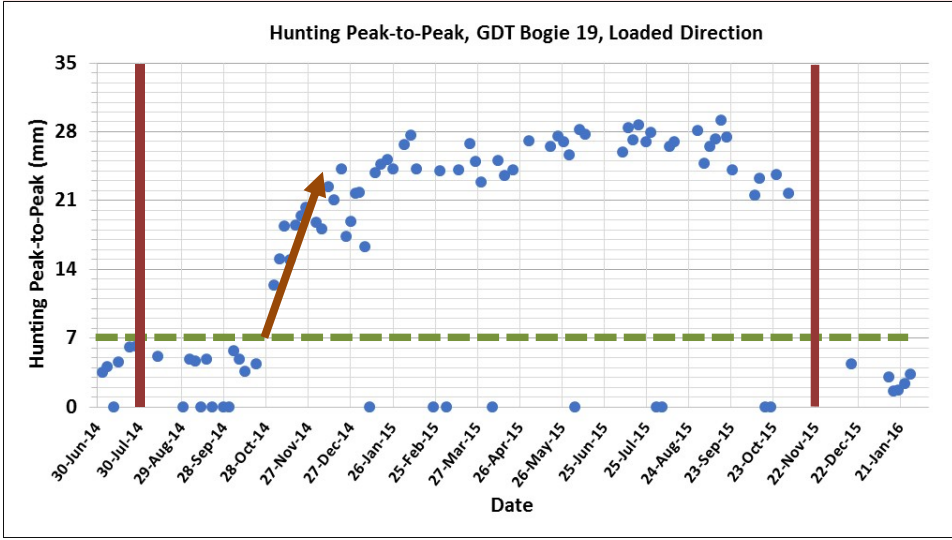
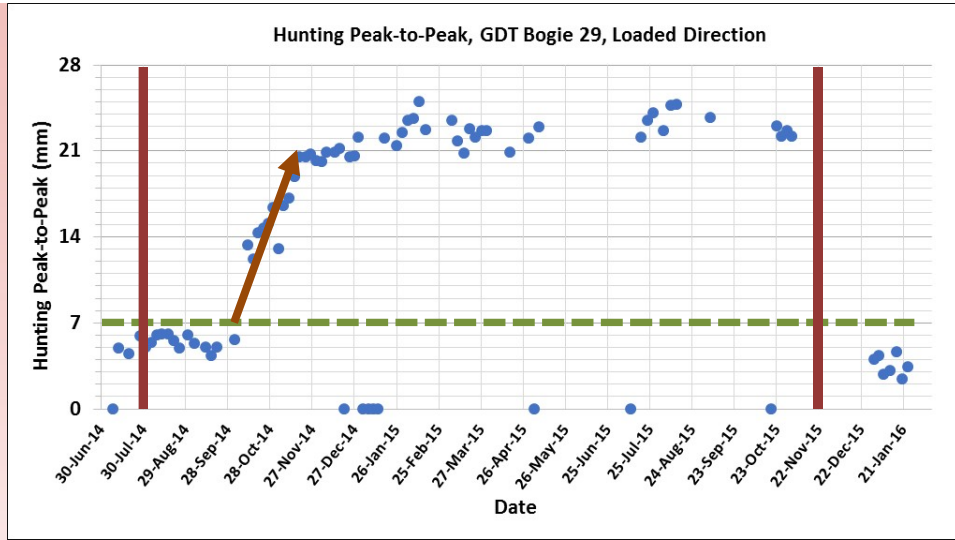
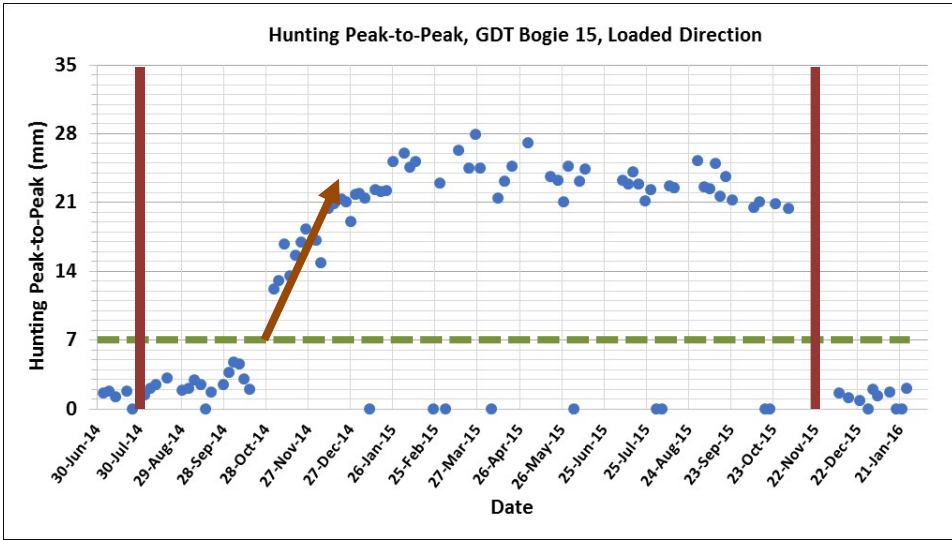




## Type (c): Sudden-onset defects when loaded







# Observations: 2014-2015

- **Almost always, a bogie that develops a gradual-onset hunting will do so in either empty, or loaded condition, but not in both**
- **Sudden-onset hunting developed in loaded condition**
- **Gradual-onset defects typically reached significantly higher severity levels than sudden-onset defects:**
  - **Gradual-onset defects continued upwards toward and beyond 35 mm**
  - **Sudden-onset defects were typically asymptotic to ~21-28 mm**



# Observations: 2014-2015

- The main wear on the rail prior to Nov-Dec 2015 was surface shelling - experienced much more RCF than wear
- Rail replaced in Mar 2013 and Nov-Dec 2015 - difference in 2015 was that also sleeper and fixings renewal, ballast maintenance, renewal, and levelling



**Was the rail change in Nov-Dec 2015 the panacea it appears to be?**

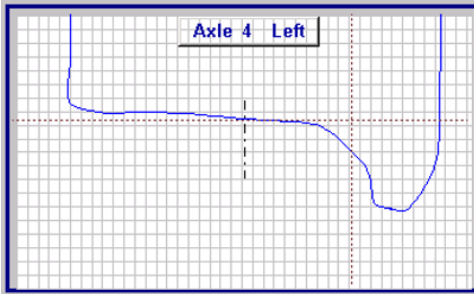
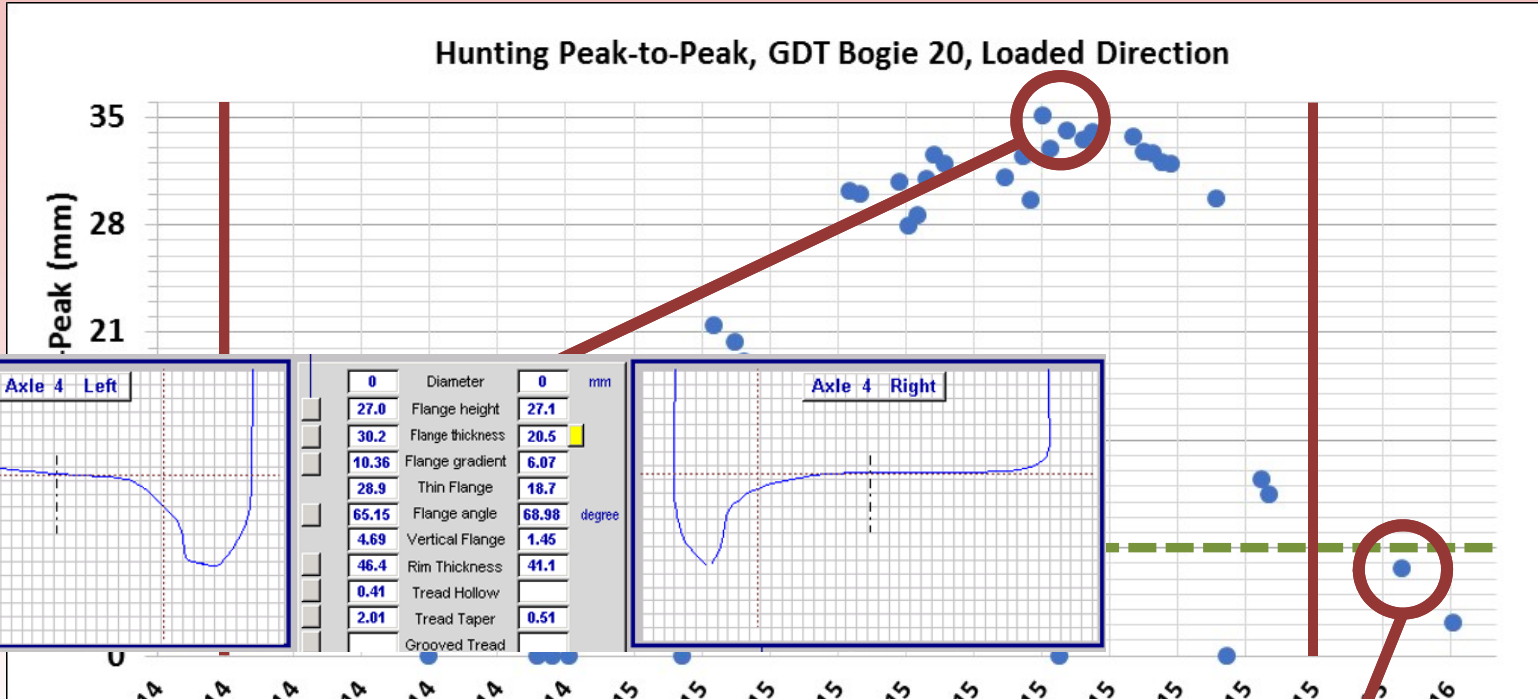
**Yes and no: it was only part of the solution**

**With the WRI, it is almost never just one thing**

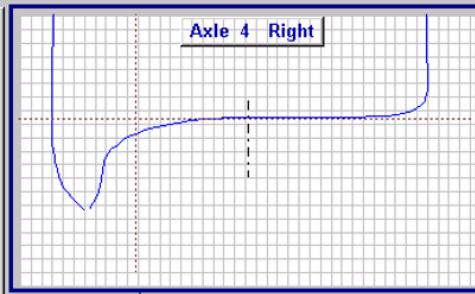
**During the same window of time, Vale repaired a lot of the trucks with extreme hunting**



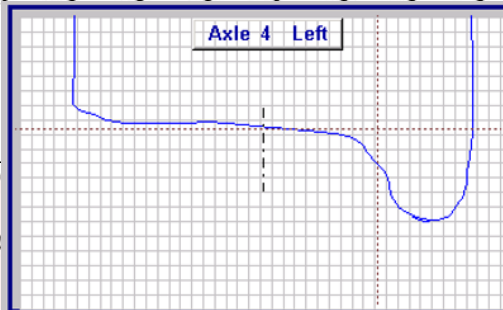
### Hunting Peak-to-Peak, GDT Bogie 20, Loaded Direction



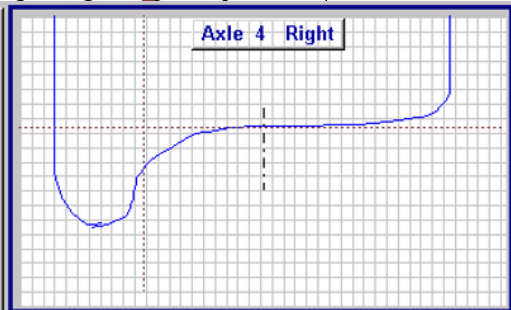
0	Diameter	0	mm
27.0	Flange height	27.1	
30.2	Flange thickness	20.5	
10.36	Flange gradient	6.07	
28.9	Thin Flange	18.7	
65.15	Flange angle	68.98	degree
4.69	Vertical Flange	1.45	
46.4	Rim Thickness	41.1	
0.41	Tread Hollow		
2.01	Tread Taper	0.51	
	Grooved Tread		



30-Jun-14  
30-Jul-14  
29-Aug-14  
28-Sep-14

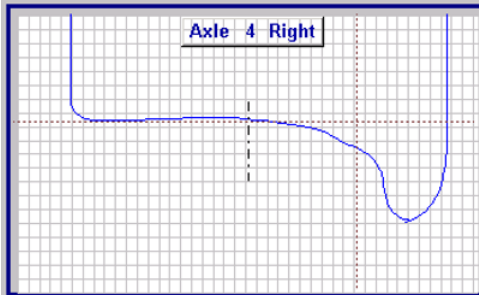
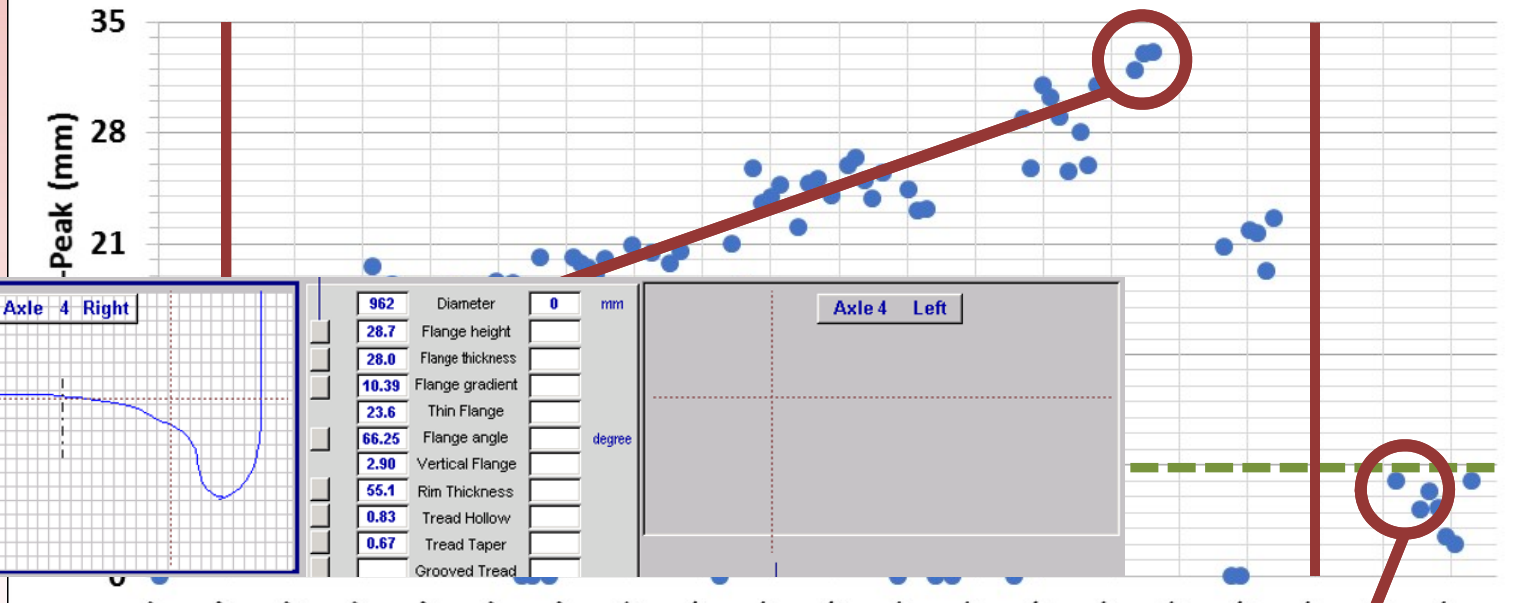


0	Diameter	0	mm
25.8	Flange height	27.2	
32.3	Flange thickness	30.7	
11.96	Flange gradient	8.94	
30.6	Thin Flange	29.1	
51.40	Flange angle	64.27	degree
4.60	Vertical Flange	5.44	
58.7	Rim Thickness	60.7	
	Tread Hollow		
1.93	Tread Taper	1.92	
	Grooved Tread		





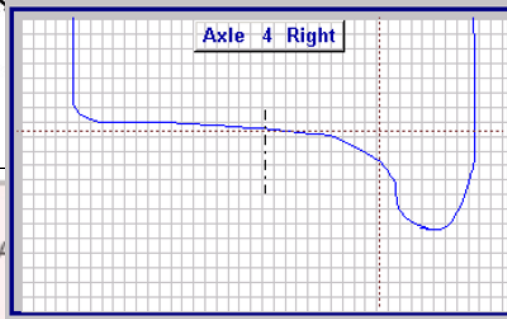
### Hunting Peak-to-Peak, GDT Bogie 26, Loaded Direction



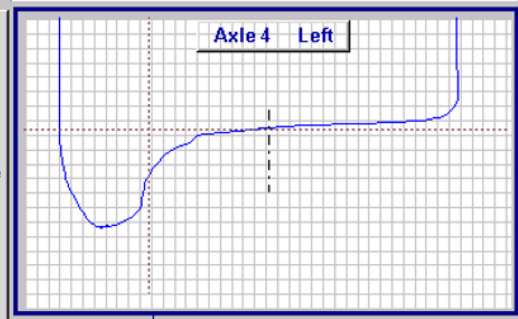
962	Diameter	0	mm
28.7	Flange height		
28.0	Flange thickness		
10.39	Flange gradient		
23.6	Thin Flange		
66.25	Flange angle		degree
2.90	Vertical Flange		
55.1	Rim Thickness		
0.83	Tread Hollow		
0.67	Tread Taper		
	Grooved Tread		



30-Jun-14  
30-Jul-14  
29-Aug-14  
28-Sep-14



0	Diameter	0	mm
27.6	Flange height	27.3	
29.7	Flange thickness	30.4	
10.19	Flange gradient	10.06	
27.5	Thin Flange	28.6	
61.27	Flange angle	60.92	degree
4.63	Vertical Flange	5.47	
54.0	Rim Thickness	55.7	
	Tread Hollow		
2.21	Tread Taper	2.32	
	Grooved Tread		



# 2016 – 2017

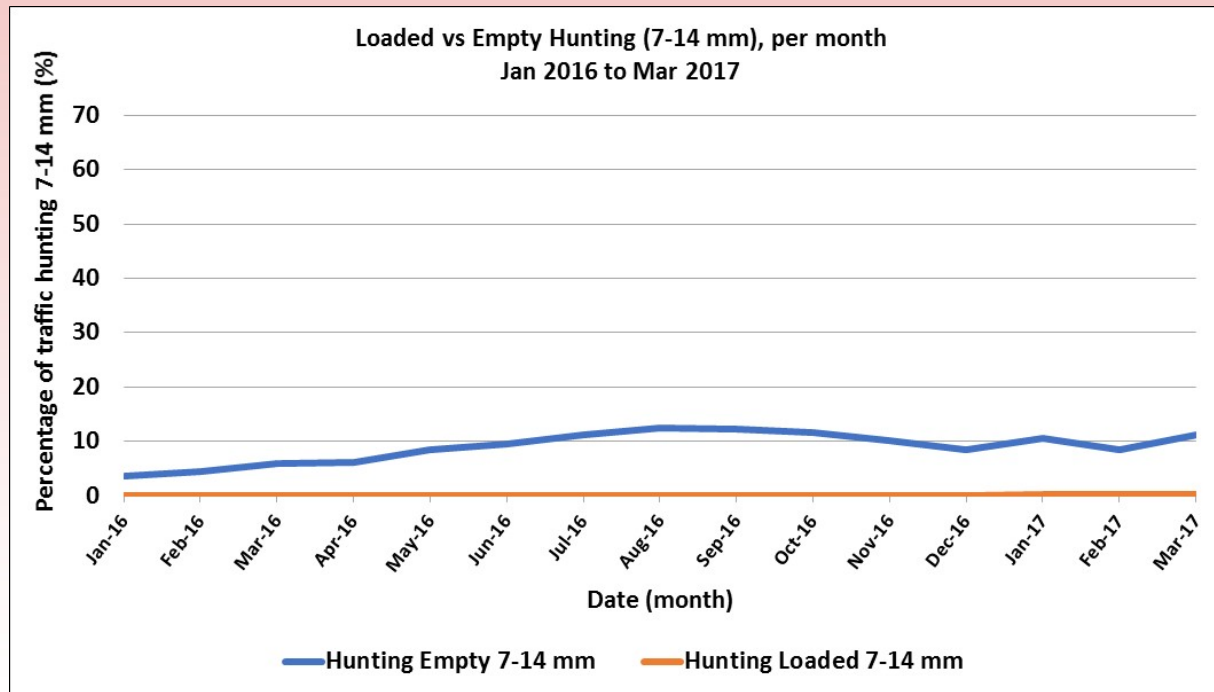


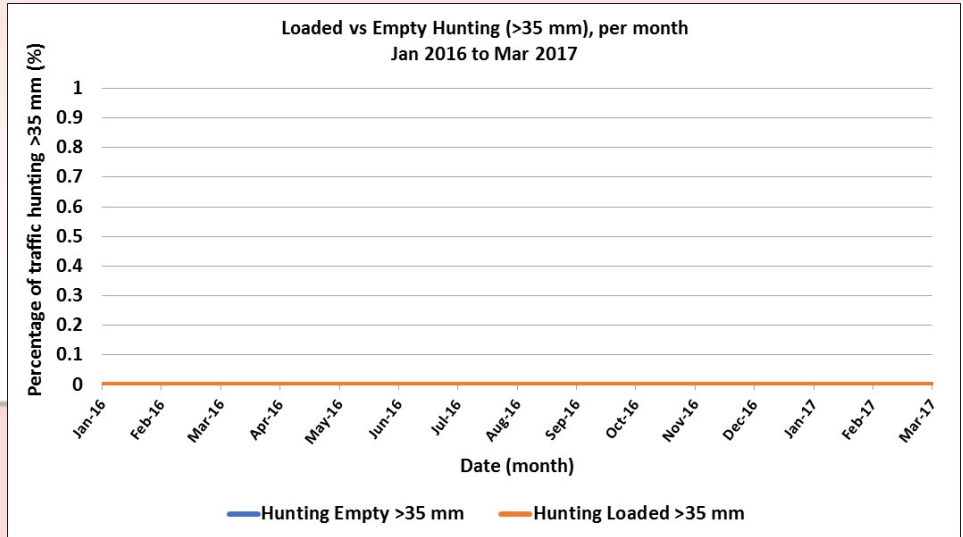
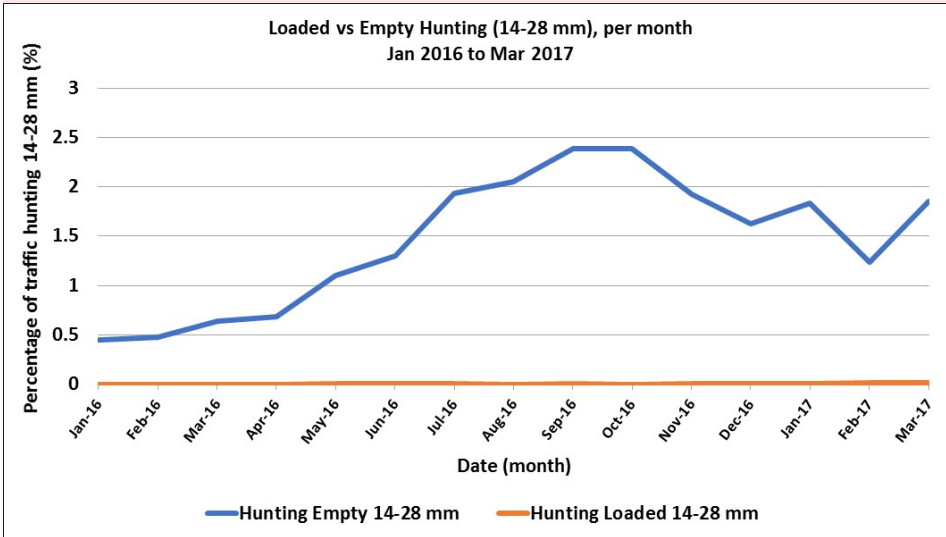
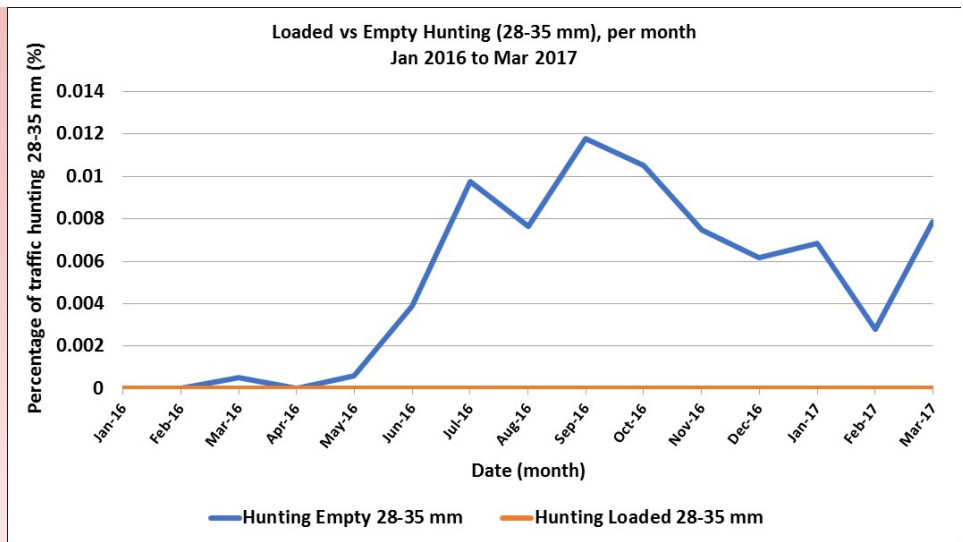
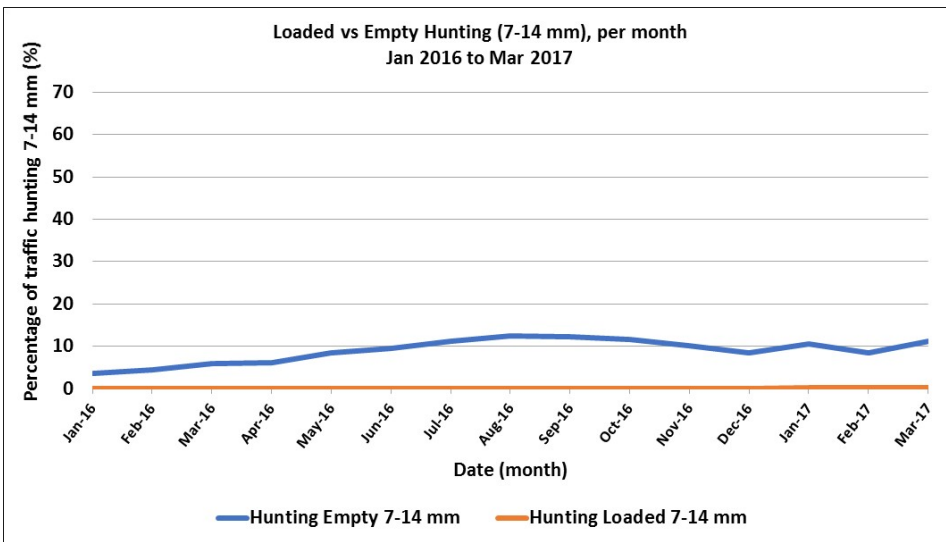
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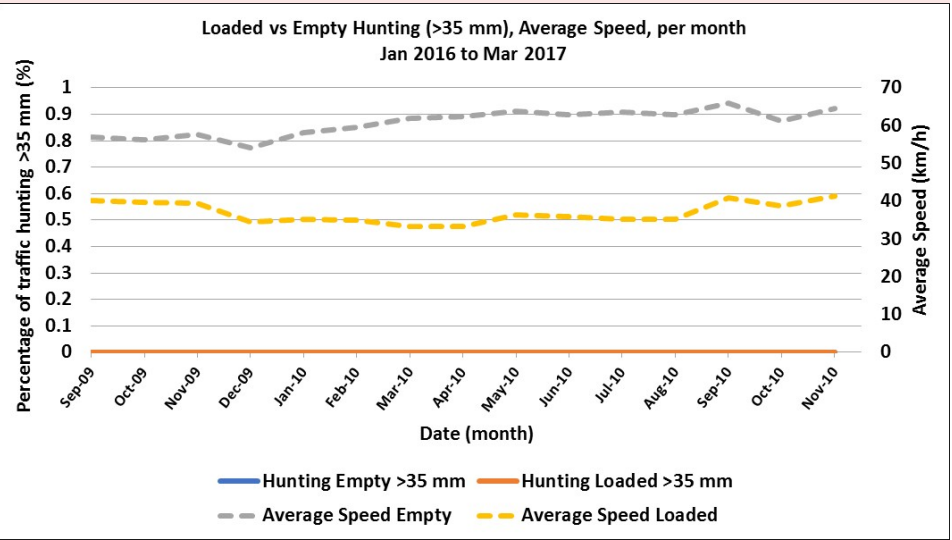
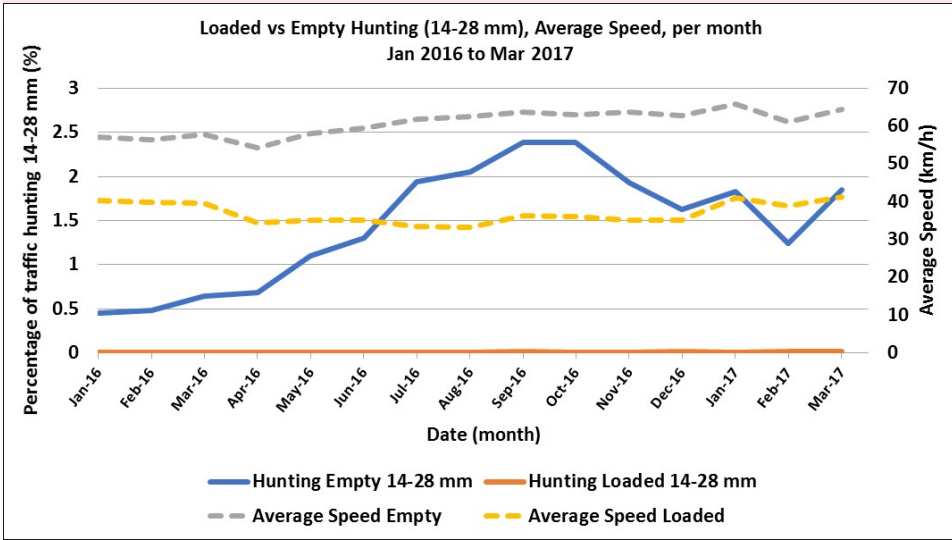
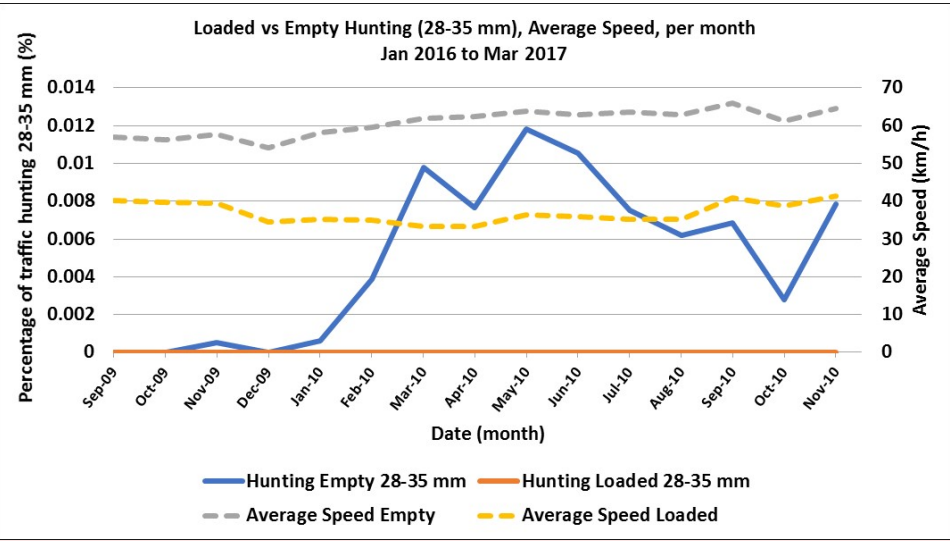
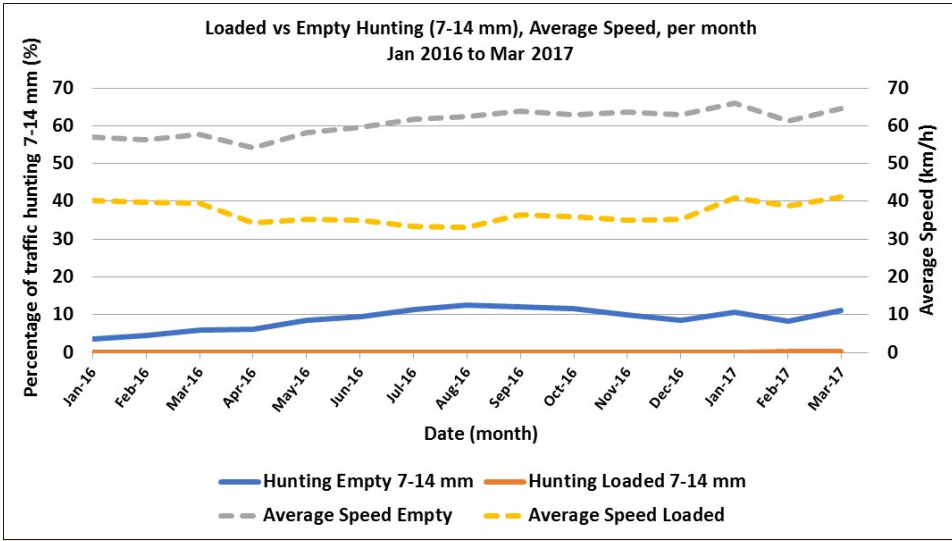
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INSPECTION  
DEVICES

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# 2016 - 2017







# Observations: 2016-2017

- **Loaded hunting: back to normal with specific trucks degrading, and no longer an indication of a population-level issue**
- **Empty hunting: back to normal with specific trucks degrading, but indication that a subset of trucks are hunting badly at higher speeds**
- **Empty hunting severity is non-linear in response to speed: a small increase in speed can correspond to a much greater increase in hunting severity (if a bogie is already unstable)**



# Overall 2009 - 2017



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# Observations: General

- **Gradual-onset defects indicates specific bogies, and individual trends are steeper when the track condition is deteriorating**
- **Sudden-onset defects with population shift in the incidence of defects, indicates a lowered tolerance of that population of bogies to a common condition (in this case, the track)**



# Supersite Data

With the assistance of Track IQ, it was possible to compare the TBOGI-HD data with data from other systems at the site:

- WCM: Wheel impact data (Track IQ)
- WheelSpec II: Wheel profile data (Mermec)
- RailBAM: Bearing acoustic data (Track IQ)

Information retrieved from Track IQ Data System (WMS)



# Supersite Data



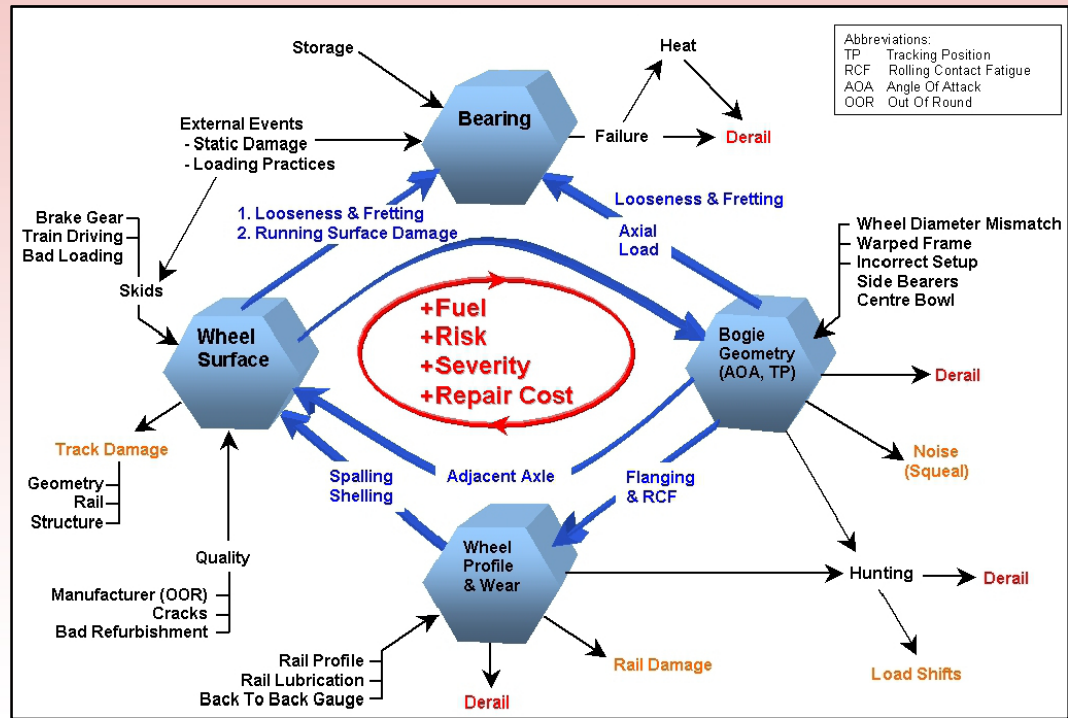
# What does it mean?

**The Wheel-Rail Interface is a relatively Closed System**

**Things do not happen in isolation**



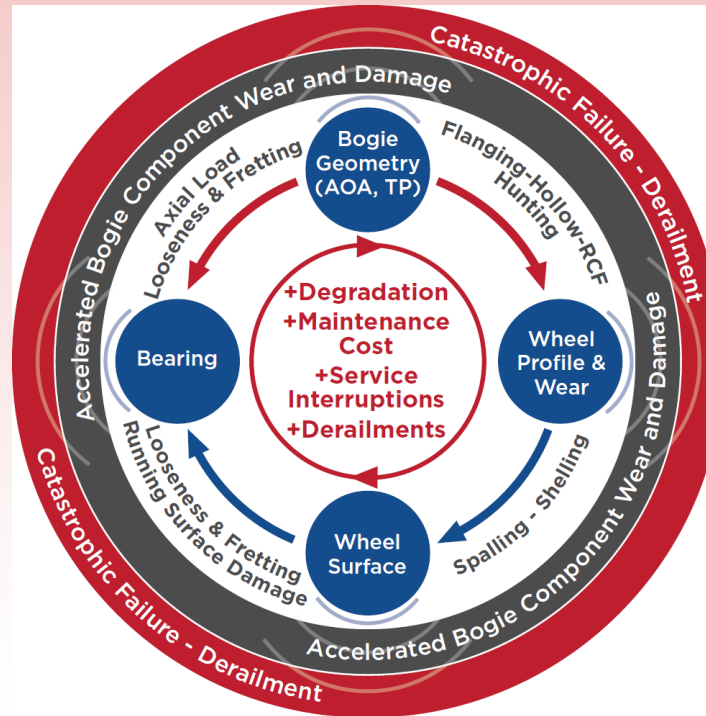
# What does it mean?



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.



# What does it mean?



Excerpt from T. Liu, T., Bladon, P., D'Acoust, D., 2016.  
Expanding the Scope of Bogie Performance  
Detectors. In: International Wheelset Congress.  
Chengdu, China. IWC2016, Nov 2016.



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# Conclusion

**Vale demonstrates different uses of the data:**

- **Identify specific bogies that are experiencing accelerated degradation due to trendable defects**
- **Warn of population-level issue by identifying a gross shift in a particular type(s) of defect**





**Thank you!**

