

Analysis of the AAR-2A Wheel Profile for Locomotives

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Outline

1. What is an AAR 2A wheel profile, and why was it developed?
2. Simulation matrix
3. Locomotive L/V results
4. Locomotive flange-rail wear results
5. Previous results for freight car wheels



AAR 2A Timeline

September 8, 2016
AAR-2A
implemented as an
alternative profile
for **turned wheels**

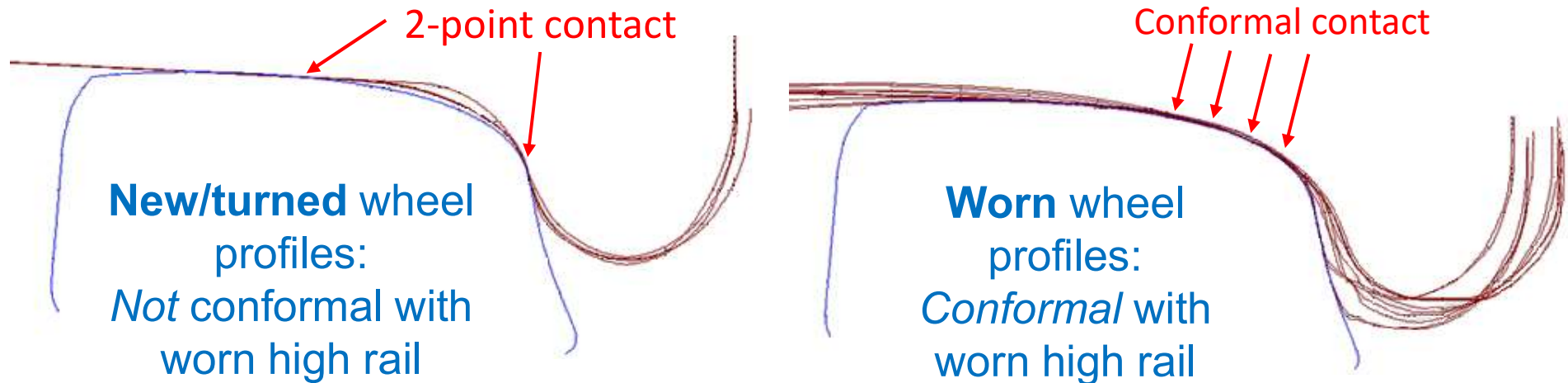
October 18, 2018
AAR-2A
implemented as an
alternative profile
for **new wheels**

January 1, 2020
All manufacturers
and wheel shops
required to use
AAR-2A profile



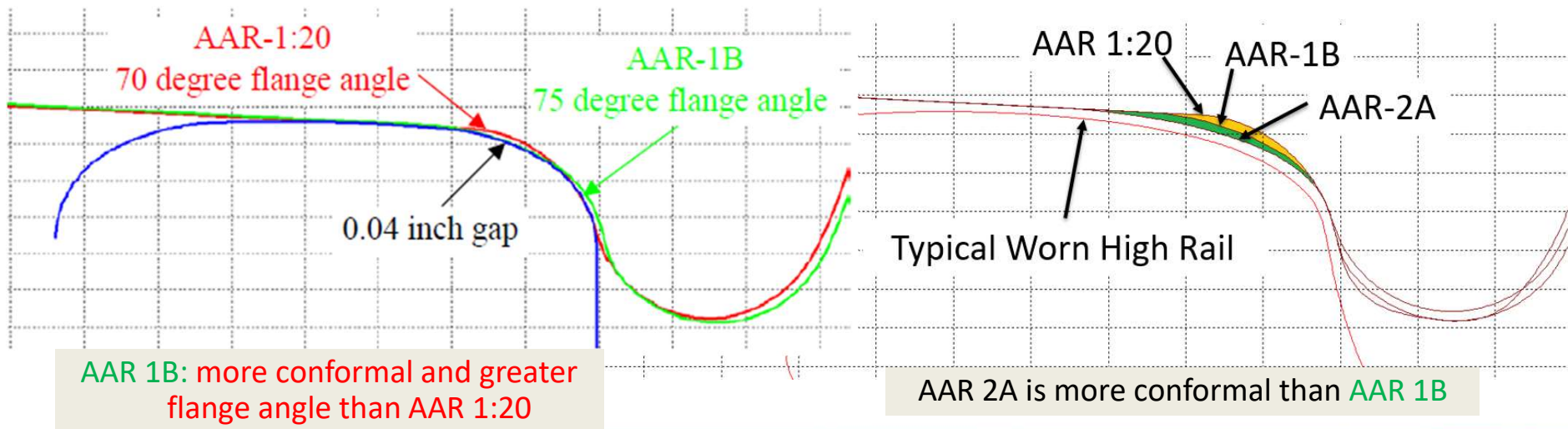
The Issues to Address...

- New/turned wheels do not conform to typically worn rail.
- New/turned wheels on curve worn rail: greater derailment risk.

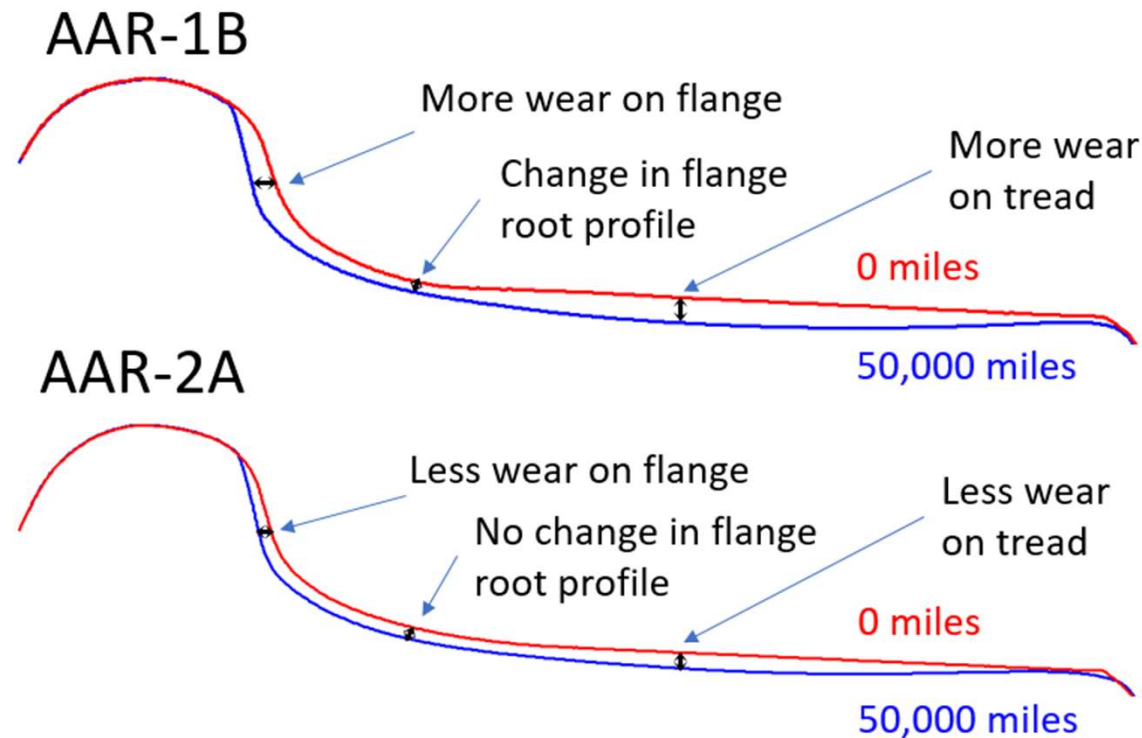


2A Profile Development

- Since all wheels wear to match the rails they typically run on, AAR-2A approximates the previous standard 1B with ~50k miles of wear



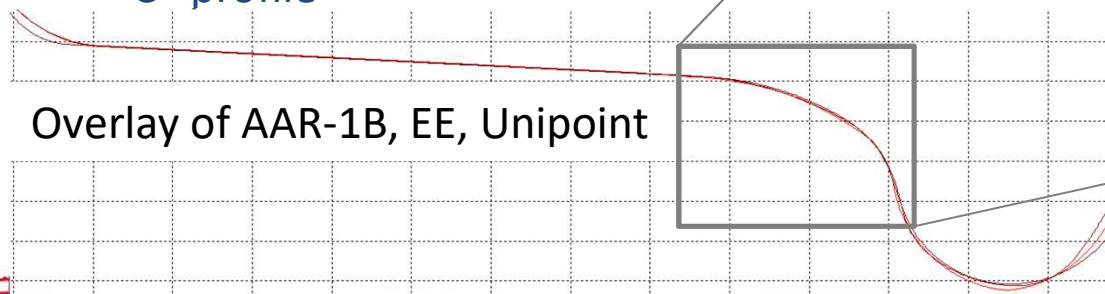
2A Profile – Designed to mimic wear



Locomotive Profiles in Use

2018 Survey of Locomotive Committee members

- New wheels: AAR-1B Wide Flange
- Trued wheels:
 - AAR-1B Narrow Flange – 5 of 7 Class 1's
 - A couple variations of "Unipoint"
 - "EE" profile (modified Heumann)
 - "C" profile

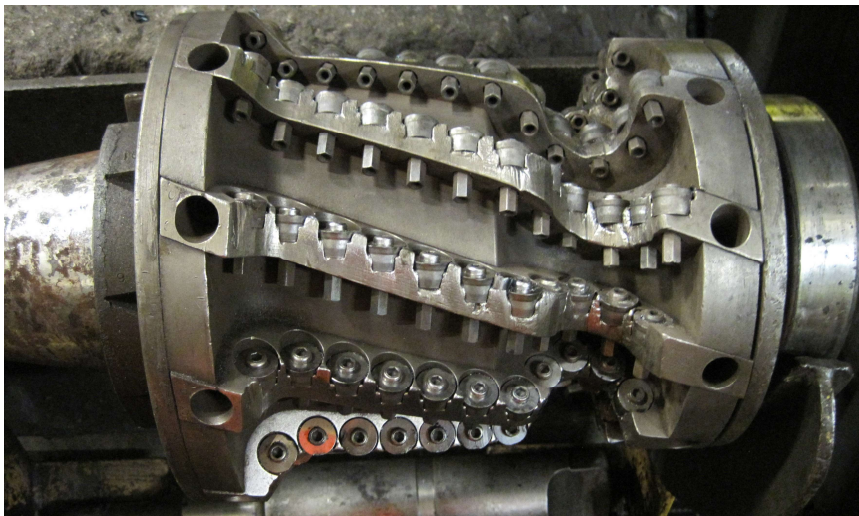


These 3 profiles do not vary by more than 0.33 mm (0.013 inch) in the contact zone (within machining tolerance)



Locomotive Profiles in Use

Milling-style profile cutter



A quick review...

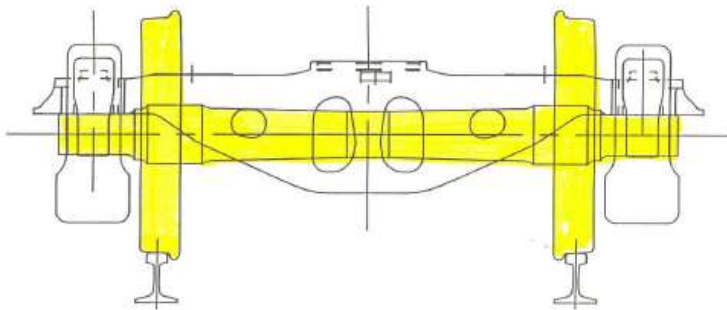


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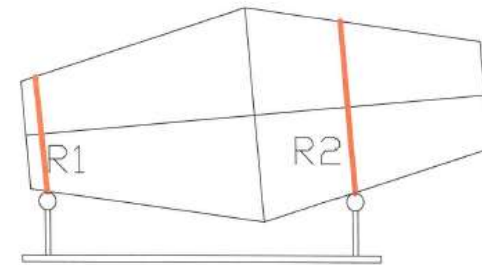
Conicity explained in one slide

Steering



Passive steering
Solid axle with pressed on wheels
Flanged wheels with 1:20 taper

Steering: Simplified Wheel



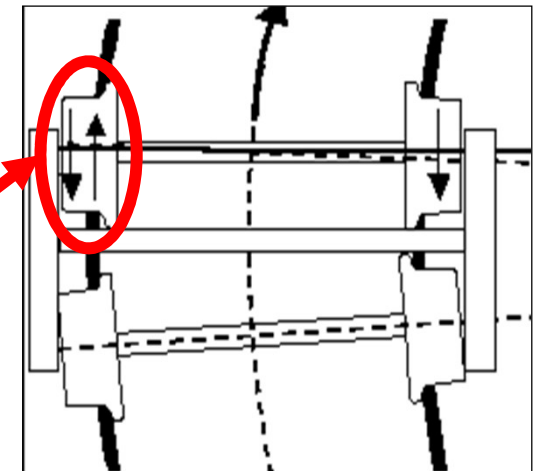
Rolling radius R1 does not equals radius R2, wheel rolls in a curve to the left . Rolling-Radius-Difference (RRD) $\neq 0$



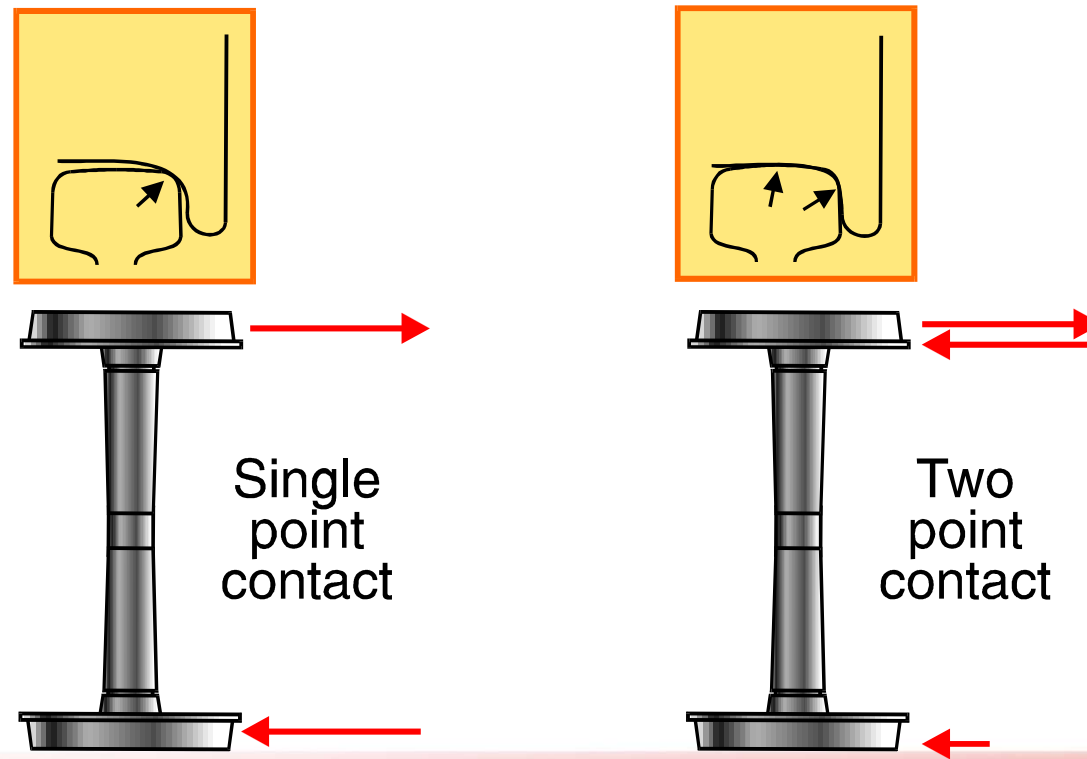
Problems with 2-point contact

- 2-point contact generates less rolling radius differential (RRD)
- 2-point contact greatly reduces beneficial truck steering forces
- 2-point contact results in high lateral forces
 - Associated with higher L/V – derailment risk
 - Associated with higher flange and gage face wear

Strong 2-
point contact

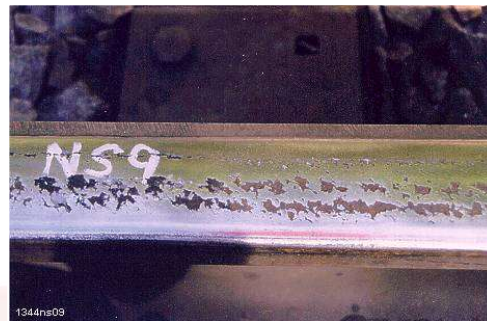


Problems with 2-point contact



Problems manifested in wear

Rail wear, RCF, and spalling

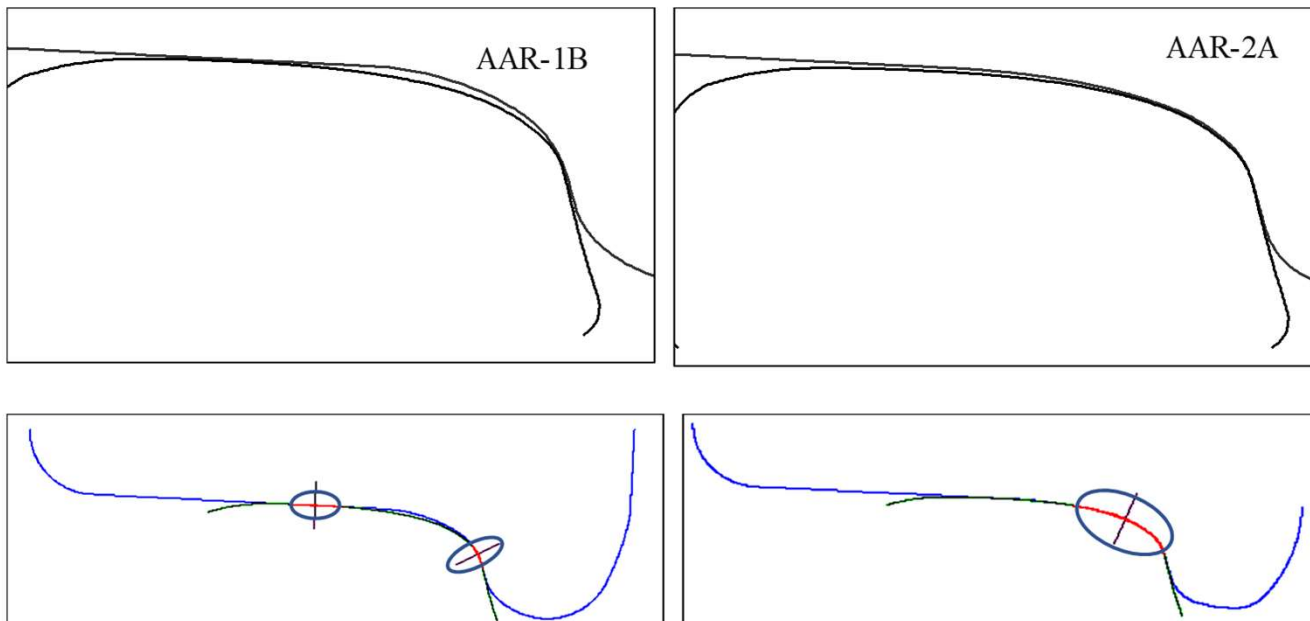


Flange wear and wheel damage



2A Contact Improvement

1B → 2A on curve worn rail



Simulation Analysis Matrix

Speeds [mph]	Curvature [deg]	Rail Profiles	W-R CoF	Traction Forces	Locomotive Trucks	Wheel Profiles
40, 50, 60 70 on tangent	Tangent	New 136RE	Dry (0.5)	Tractive + braking forces	Six-wheel Radial	1B WF
			Gage face only (0.2)			1B NF
Balance Speed and ±3" on curves	1-, 2-, 4-, 6- , 8-, 10-, 12-degree curves	Typical worn	TOR+GF	Free- rolling	Six-wheel Fixed axle	2A WF
						2A NF
						C contour

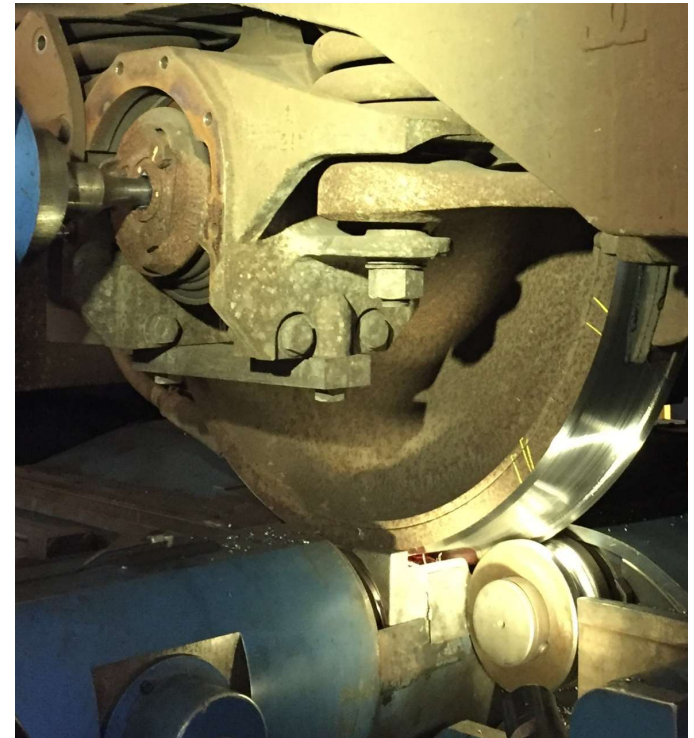
“TOR+GF” = top of rail friction modifier (0.35) and gage face grease (0.2)

“WF” = wide flange; “NF” = narrow flange



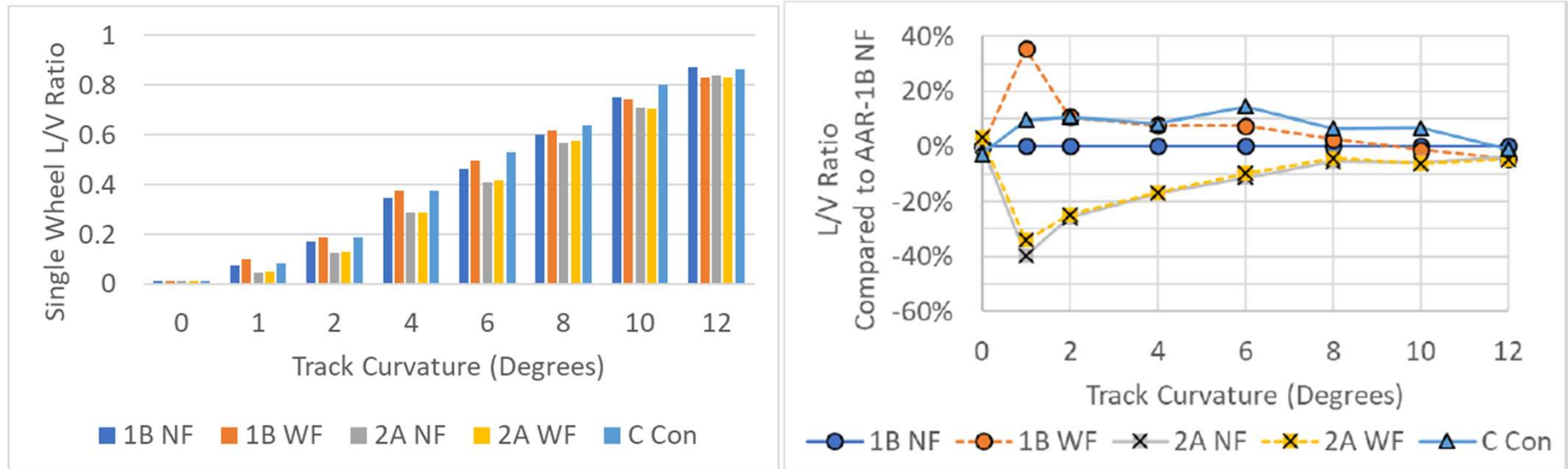
Key Findings for 2A Profiles

- NUCARS® simulations showed improved performance in terms of:
 - Flange and gage corner wear in curving
 - L/V ratios (reduced derailment risk)



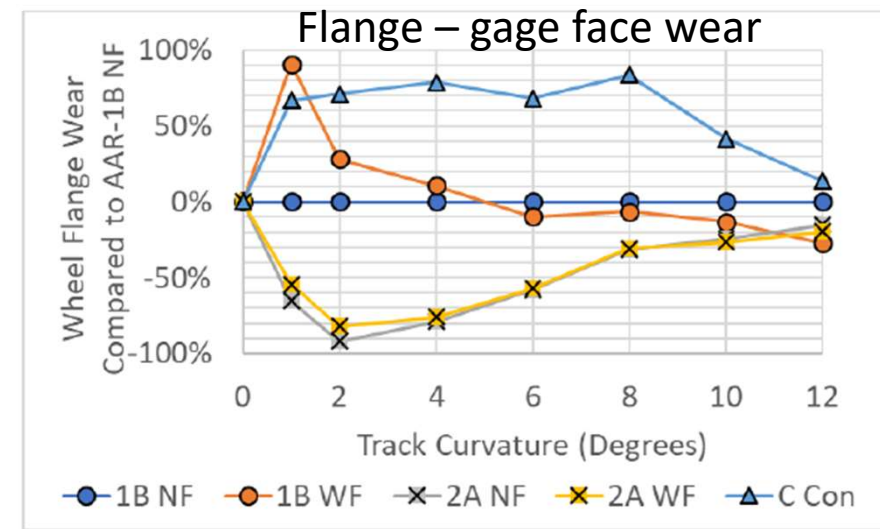
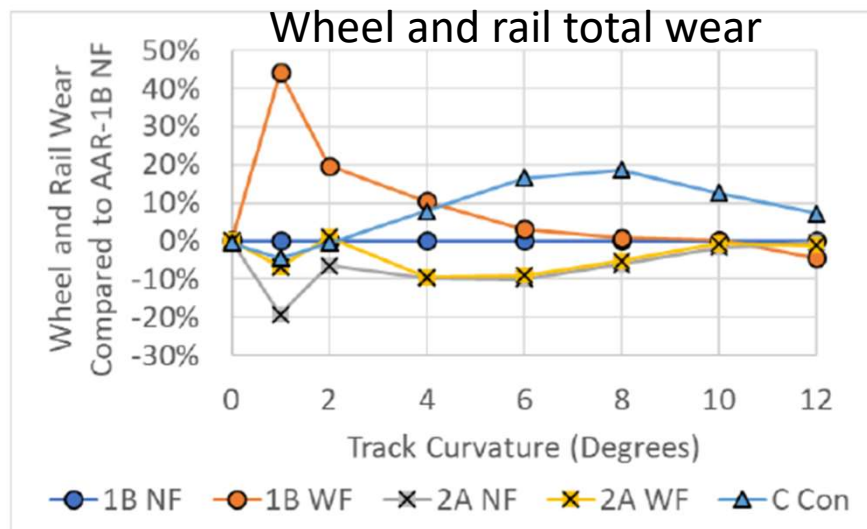
Results – L/V Improvement

- Lower L/V values reflect increased safety against derailment.



Results – Wear Reduction

- Conformal contact means better wheelset steering
- Better steering means lower creep forces and less wear

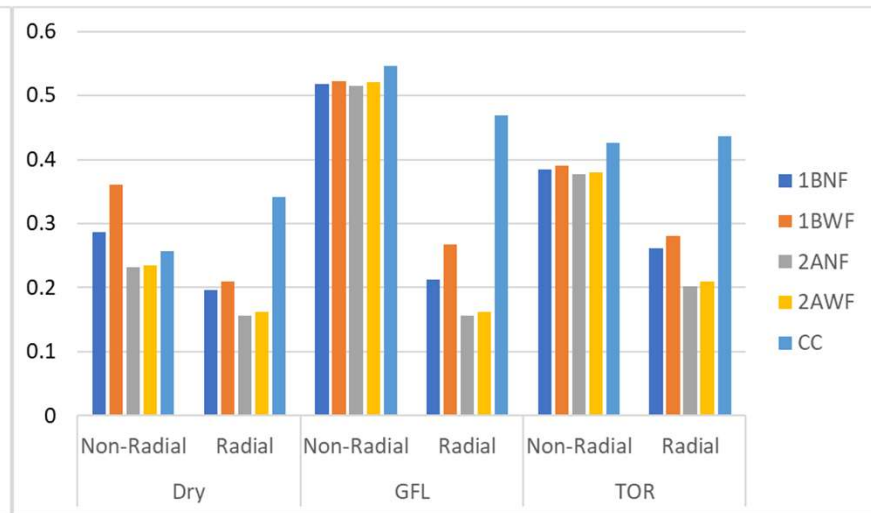
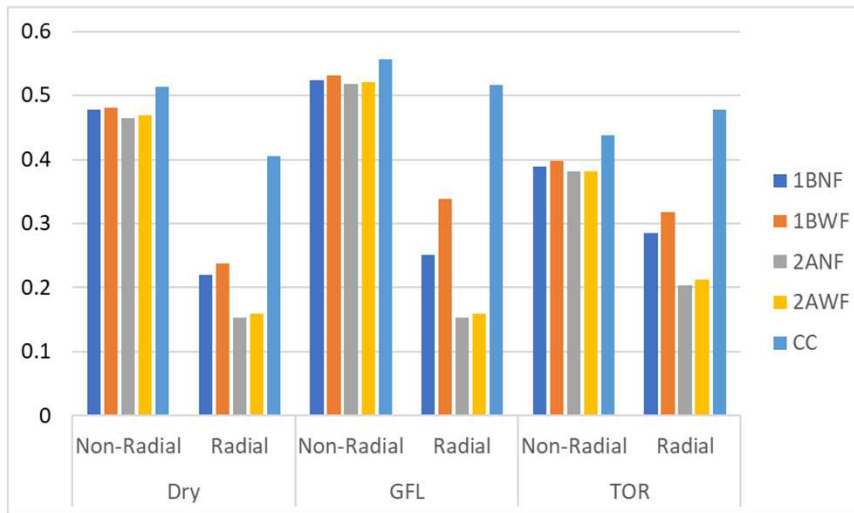


L/V Results – Steering

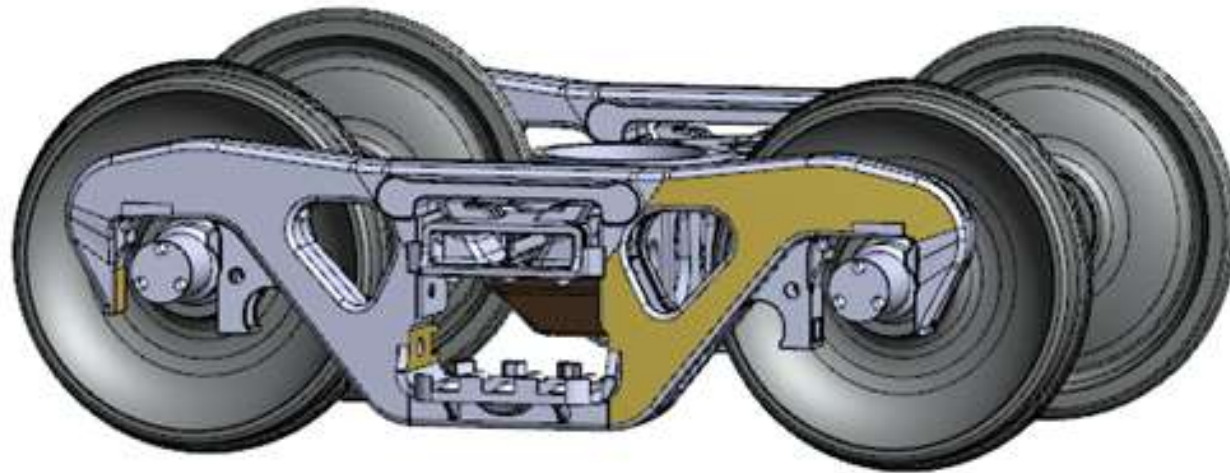
- Radial trucks take advantage of 2A steering

6-deg curve, new rail, all speeds

6-deg curve, all rail, all speeds



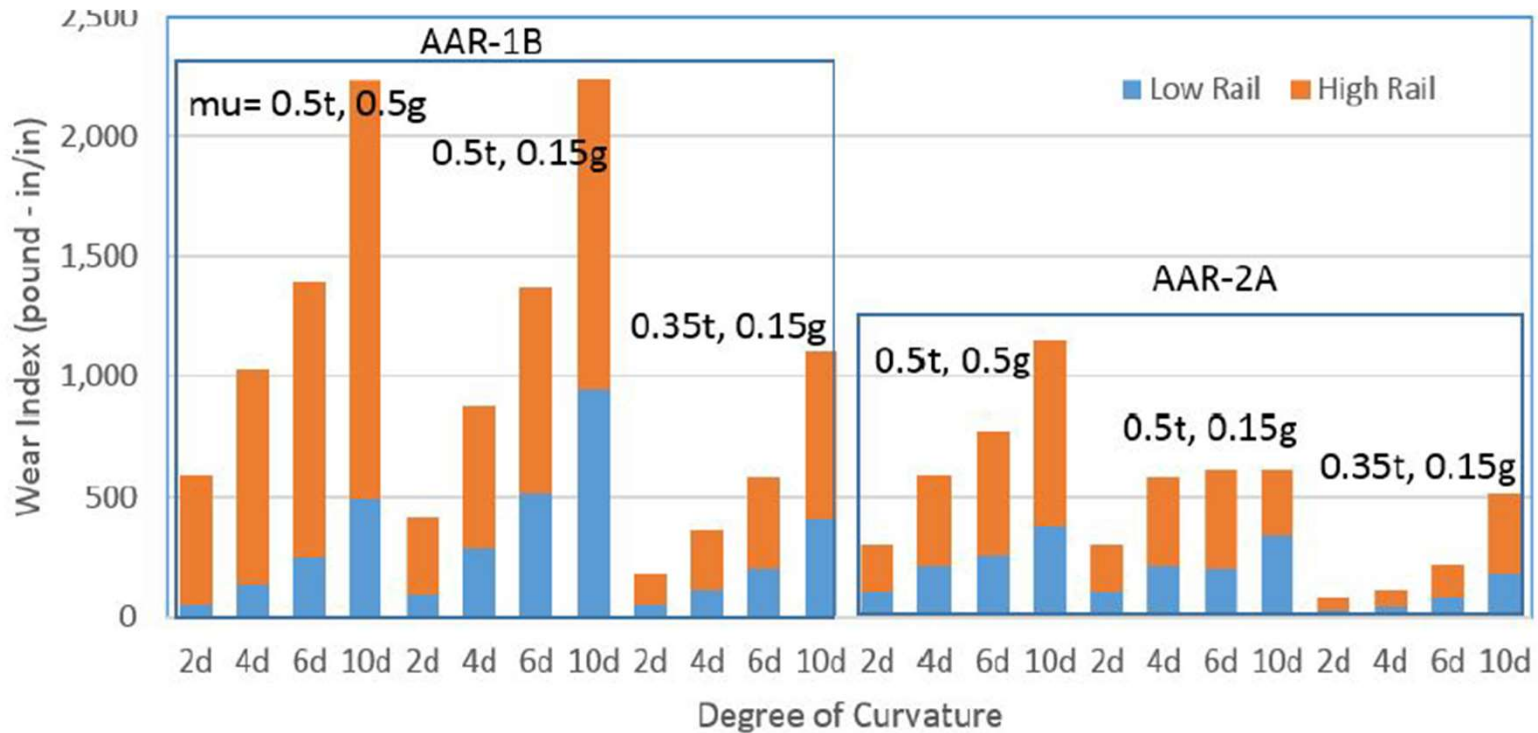
Review: freight car truck results



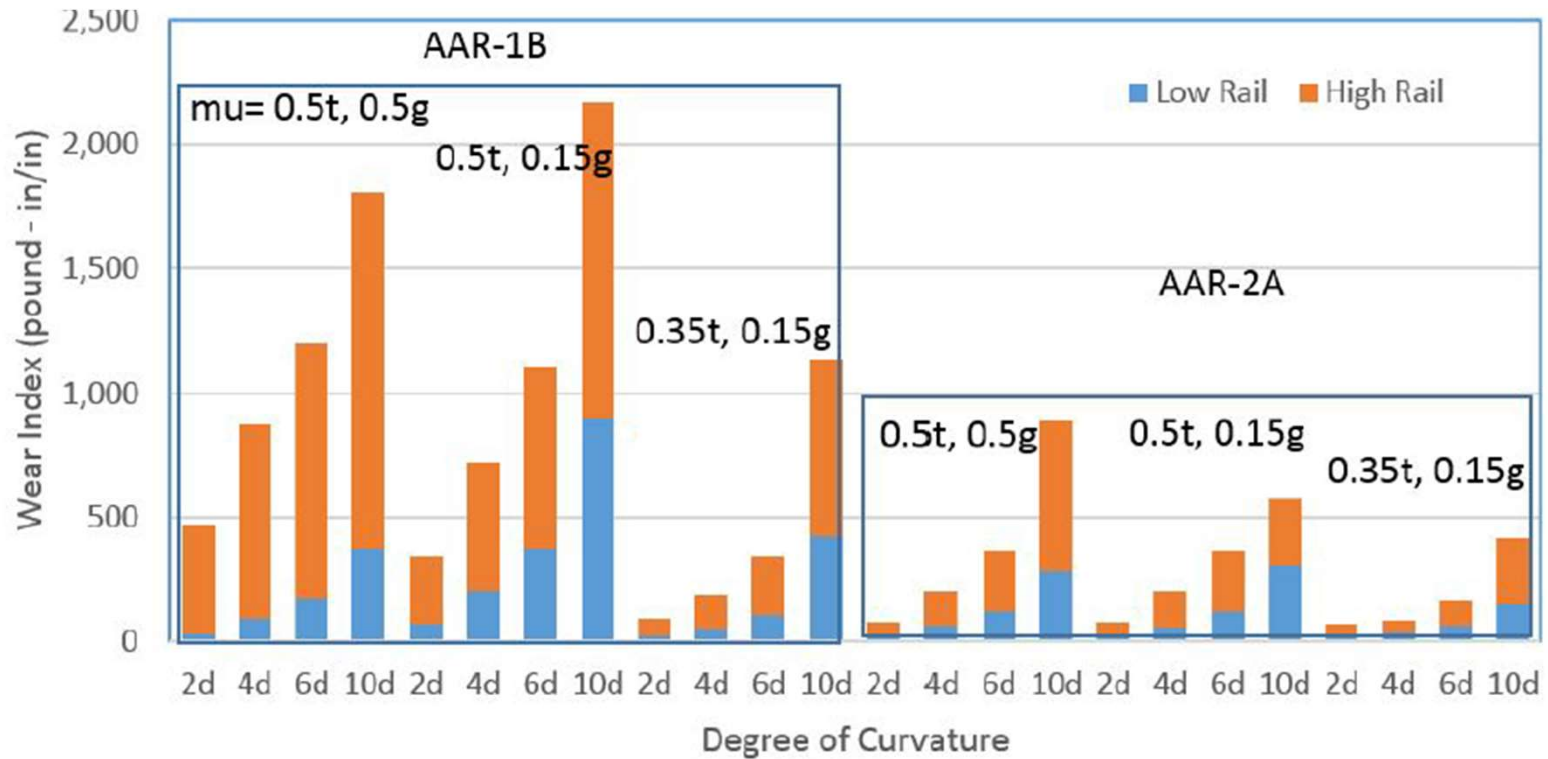
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1B → 2A: Standard 3-piece Trucks



1B → 2A: M-976 Trucks



Conclusions

AAR-2A profiles

- Reduce 2-point contact and improve steering
- On locomotive wheels can reduce derailment risk and flange-gage face wear
- Reduce wear on 3-piece trucks
 - More so on M-976 trucks
 - More so on light to moderate curves



Questions?

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