Developing a Program to Measure and Manage Wheel/Rail Equivalent Conicity at Amtrak

Using wheel/rail measurements and automated processing techniques to predict vehicle dynamics on the Northeast Corridor

Steve Chrismer – Senior Engineer, LTK Engineering Services (formerly with Amtrak)
schrismer@ltk.com

Michael Craft – Principal Engineer - Track Geometry, Amtrak
michael.craft@amtrak.com

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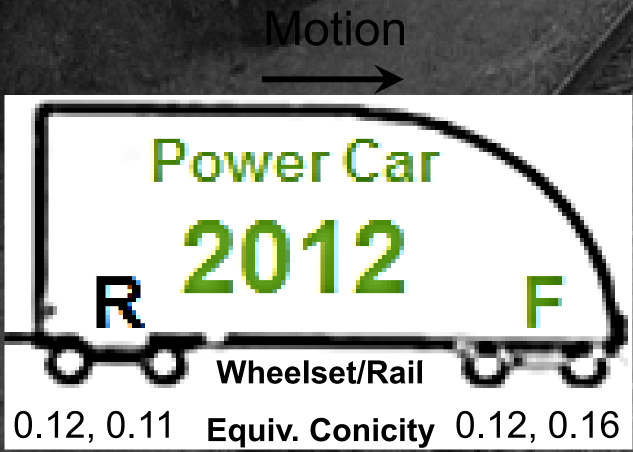
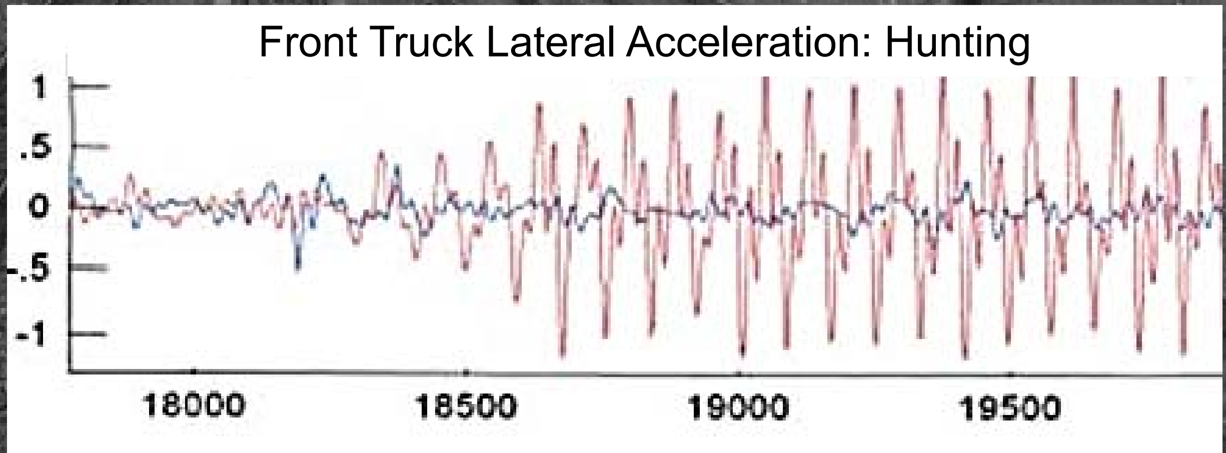
As track speeds increase, managing the equivalent conicity of wheelsets becomes critical to prevent truck hunting

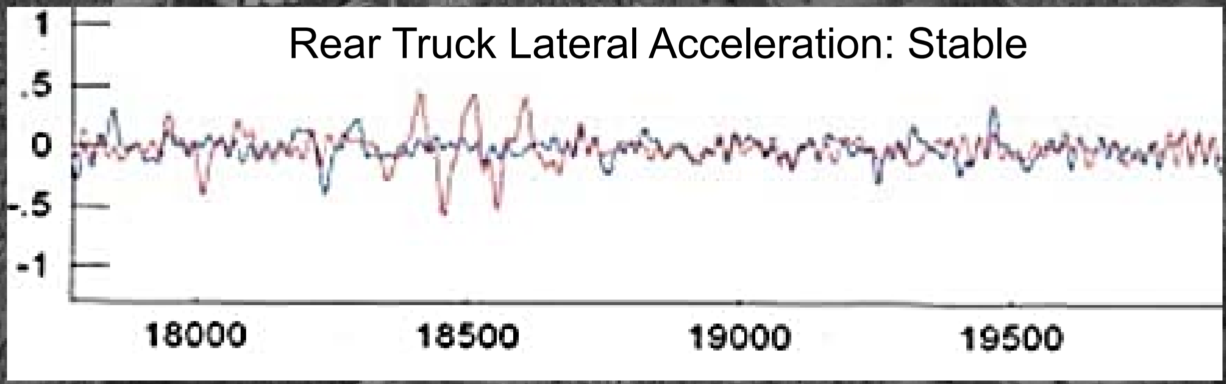
- Amtrak mandated to increase maximum operating speed of Acela trainset to 160 mph (257 kph)
- During testing phase, Acela Power Car lead truck lateral acceleration >0.3g rms measured at 160+ mph
- Various track and vehicle parameters were assessed for their contribution to these hunting events

Wheel/Rail equivalent conicity appeared to be a significant factor, prompting development of management program

Measured Hunting Instability of Lead Acela Power Car Truck During Testing at 160+ mph

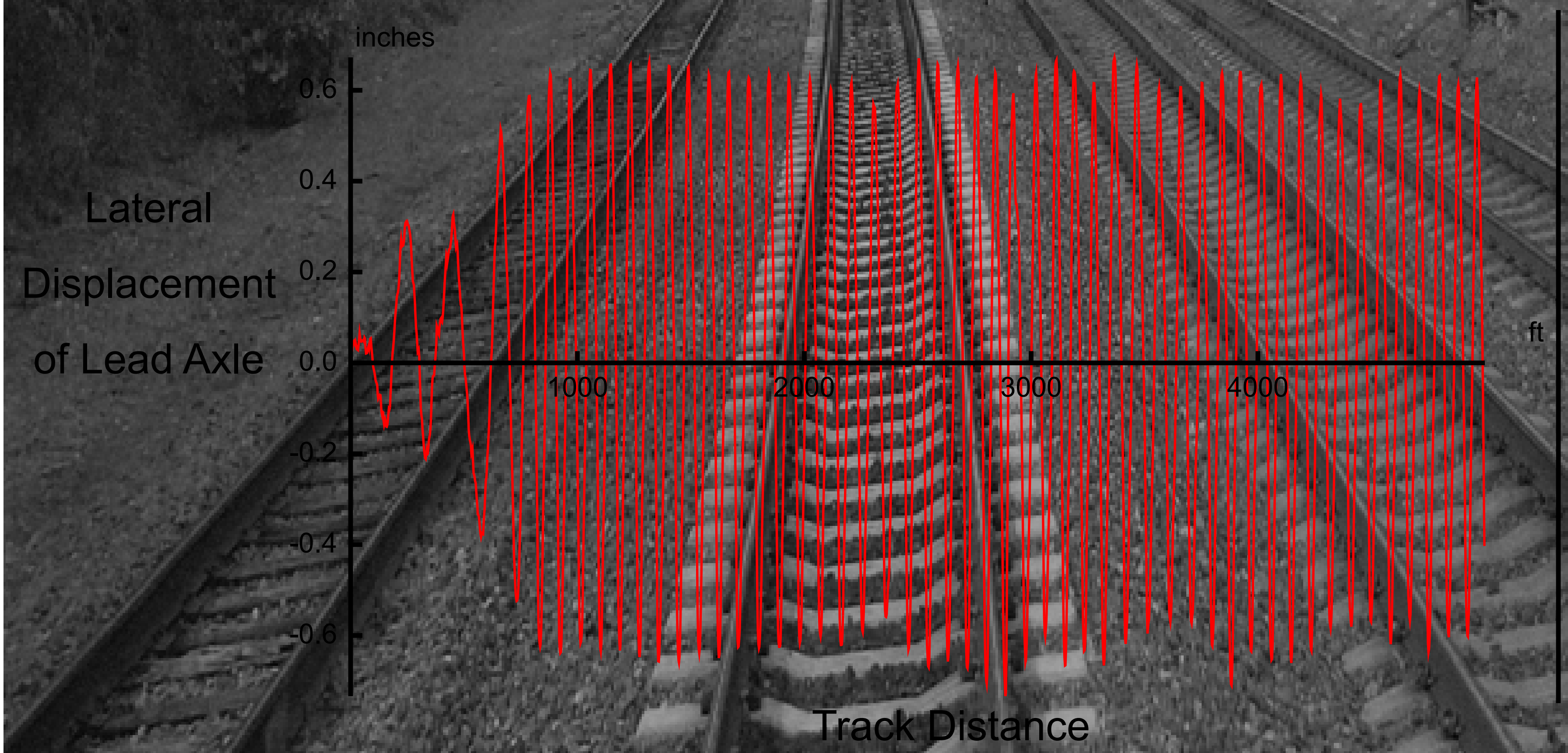


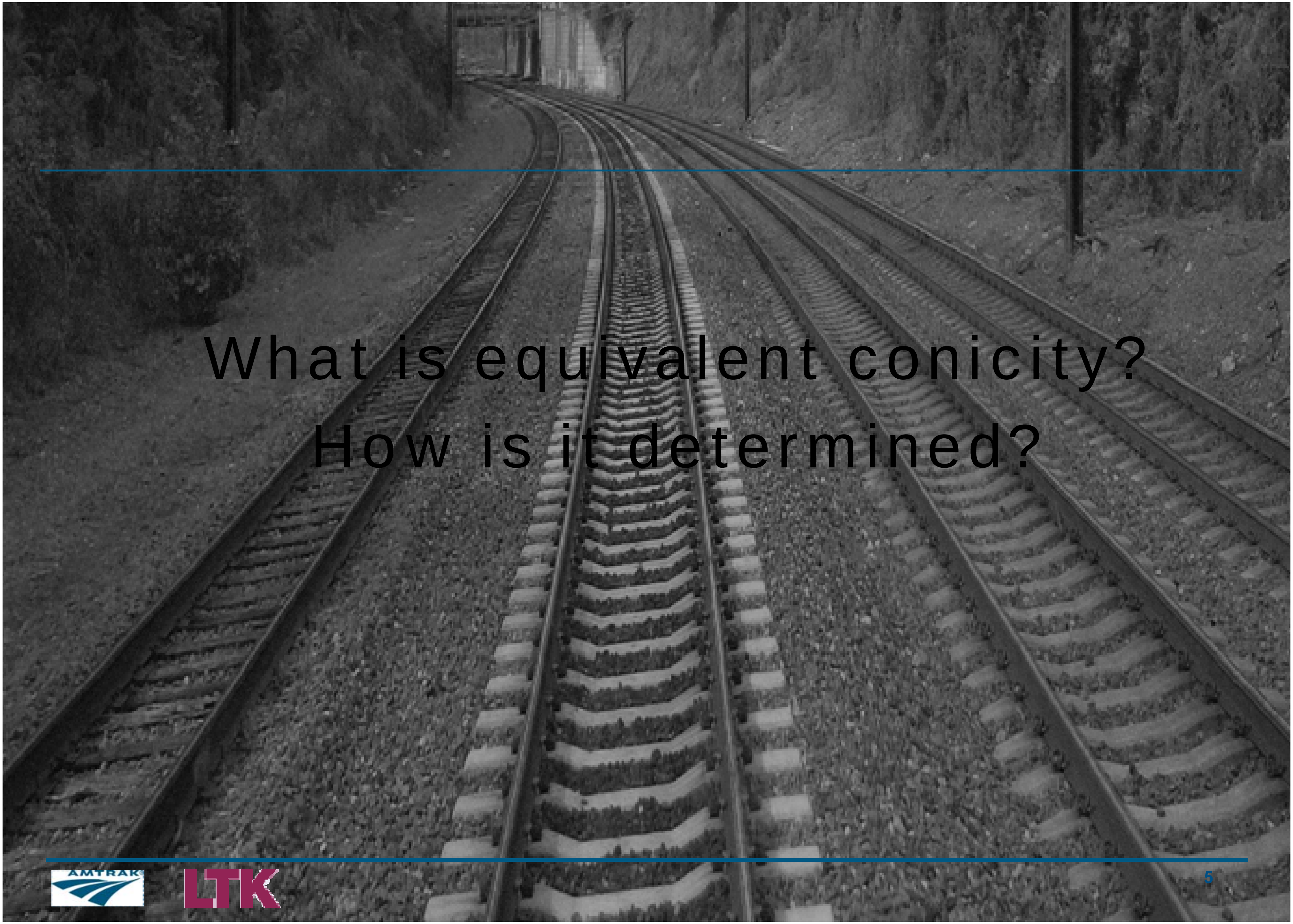




This hunting behavior can be predicted and further investigated with analysis….

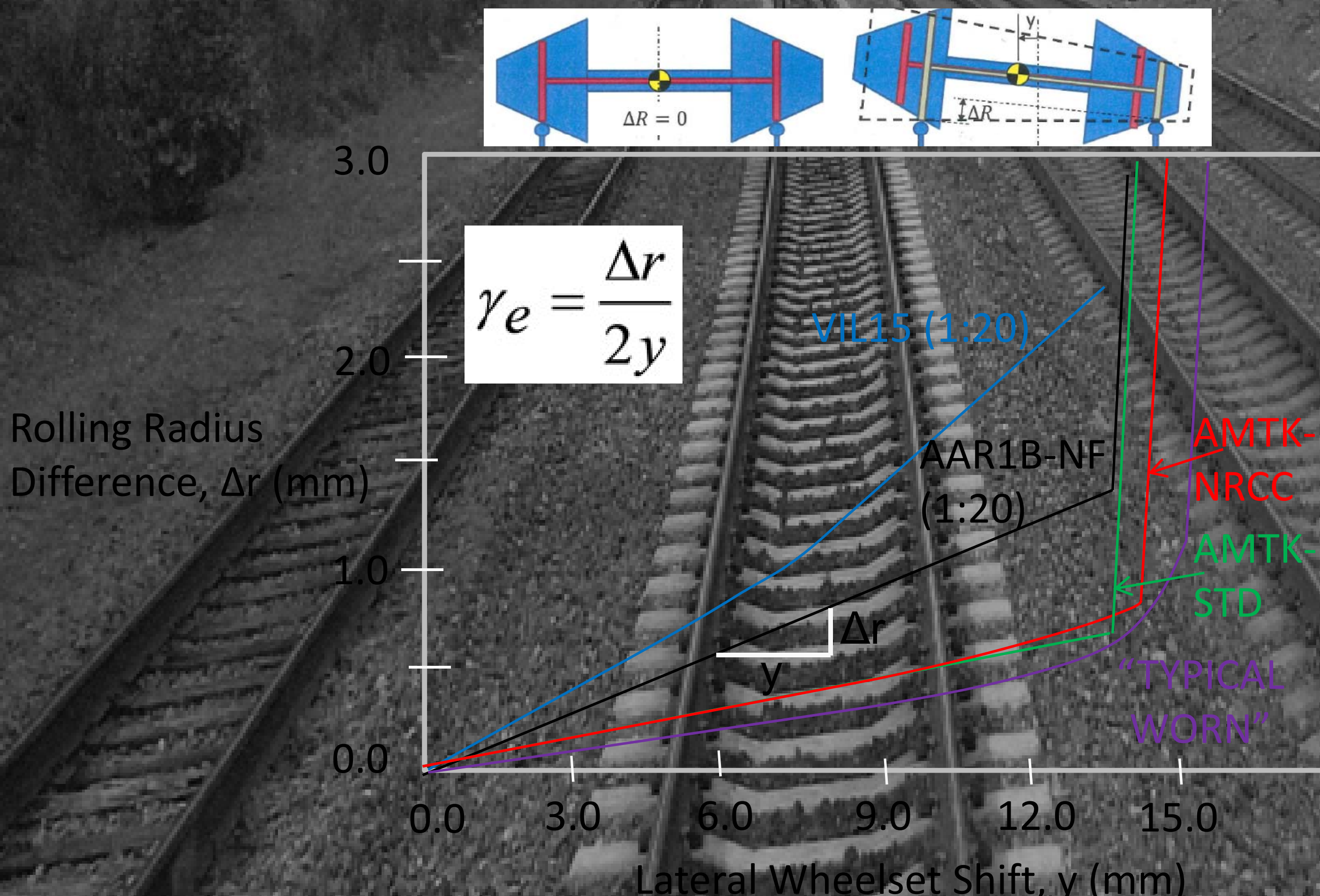
Acela PC Lead Wheelset Lateral Displacement with Worn Wheel/Rail Profiles Predicted by Analysis at 160 mph





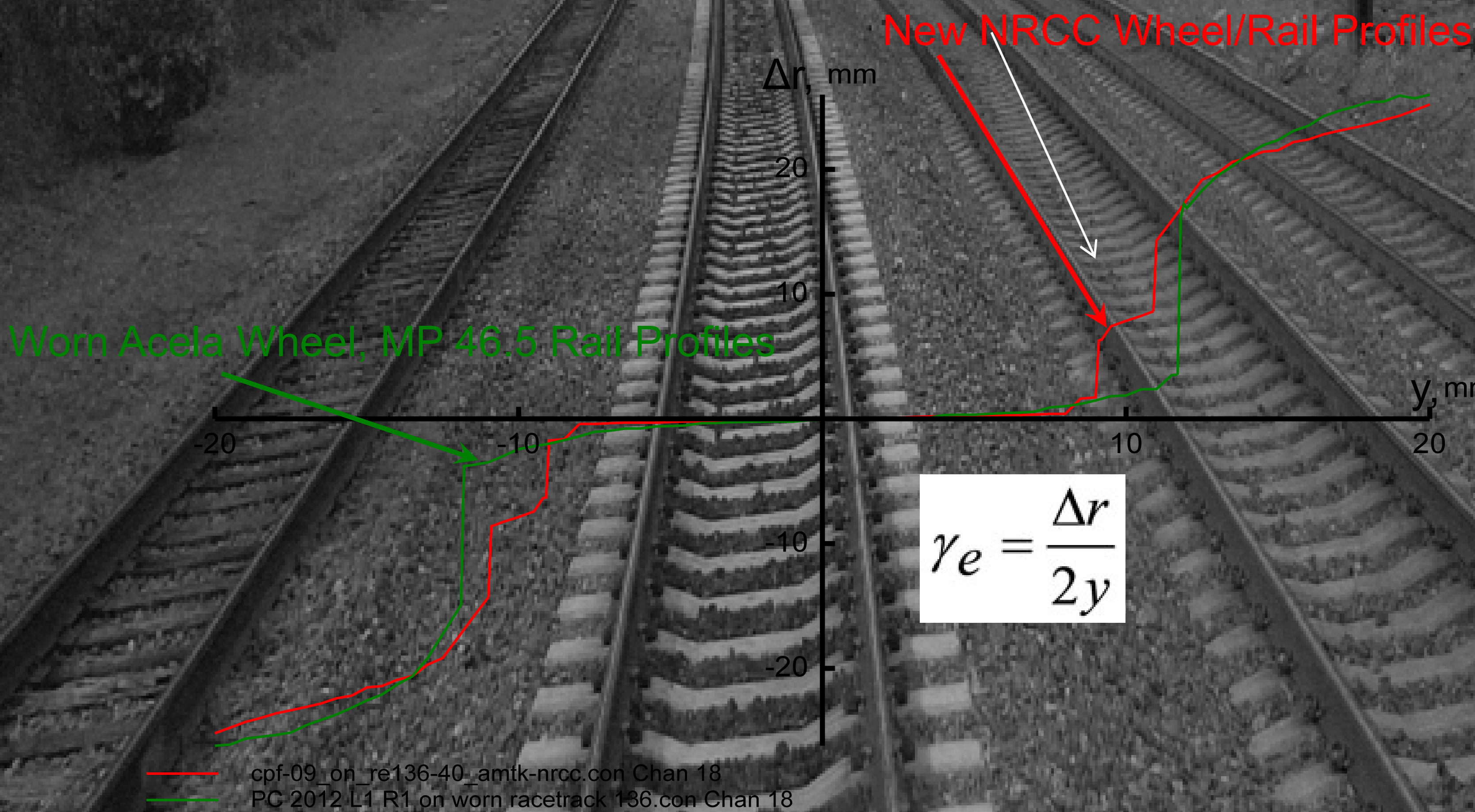
What is equivalent conicity?
How is it determined?

Rolling Radius Difference vs. Lateral Wheelset Displacement for Several Wheel Profiles



However, the equivalent conicity is determined by the interaction of <u>wheel and rail profiles</u>.

Equivalent Conicity (γ_e) Results from the Rolling Radius Difference Produced by Lateral Wheelset Motion



$$\gamma_e = \frac{\Delta r}{2y}$$

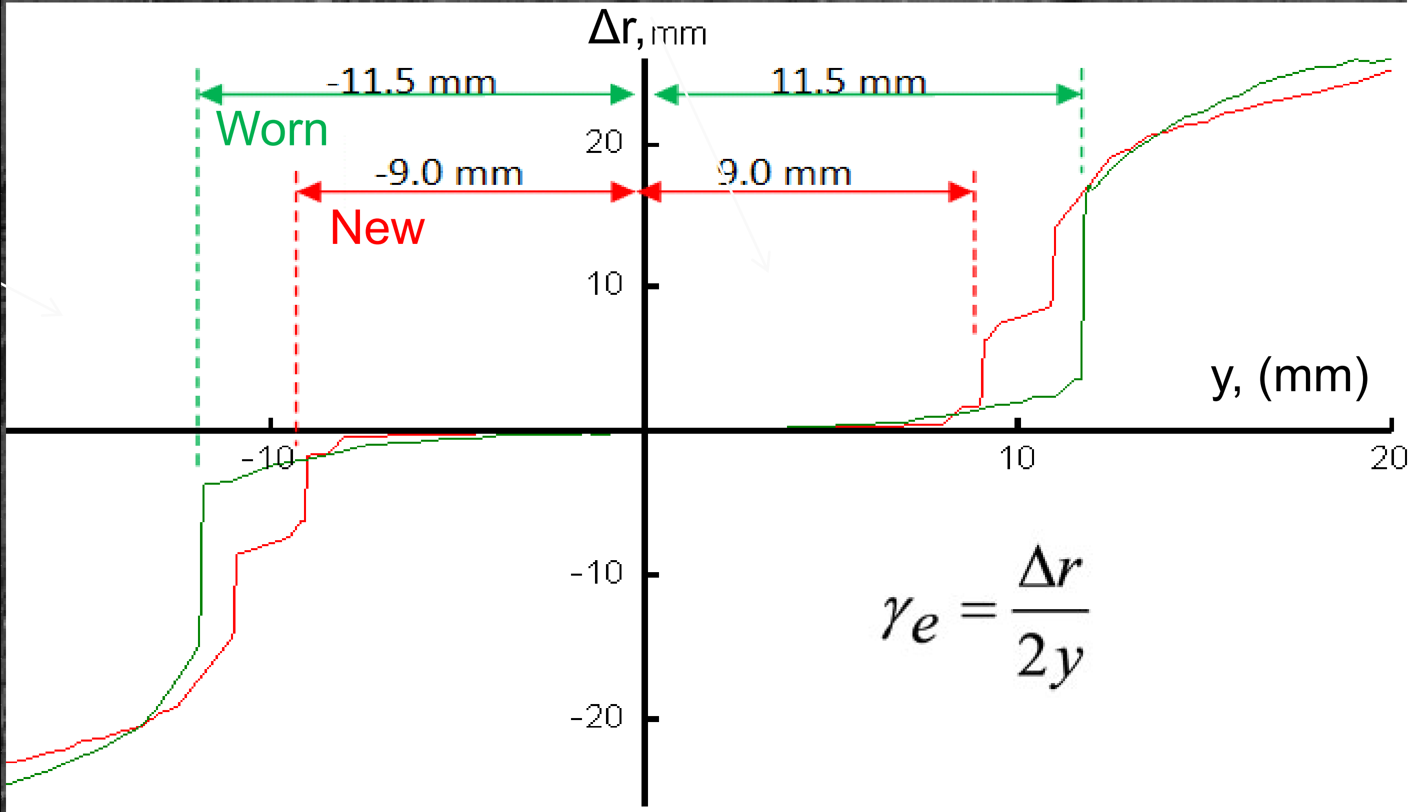
Equivalent Conicity Calculated from Rolling Radius Difference for New and Worn NRCC Wheel/Rail Profiles

NEW

mm	γ_e
1	0.02
1.5	0.029
2	0.027
2.5	0.024
3	0.024
3.5	0.026
4	0.025
4.5	0.025
5	0.025
5.5	0.025
6	0.025
6.5	0.025
7	0.025
7.5	0.025
8	0.025
8.5	0.037
9	0.085
9.5	0.149
10	0.177
10.5	0.212
11	0.263
11.5	0.305
12	0.345
12.5	0.385
13	0.419

WORN

mm	γ_e
1	0.038
1.5	0.027
2	0.04
2.5	0.036
3	0.039
3.5	0.04
4	0.04
4.5	0.04
5	0.038
5.5	0.041
6	0.042
6.5	0.046
7	0.049
7.5	0.052
8	0.056
8.5	0.059
9	0.065
9.5	0.07
10	0.076
10.5	0.081
11	0.162
11.5	0.164
12	0.233
12.5	0.276
13	0.317



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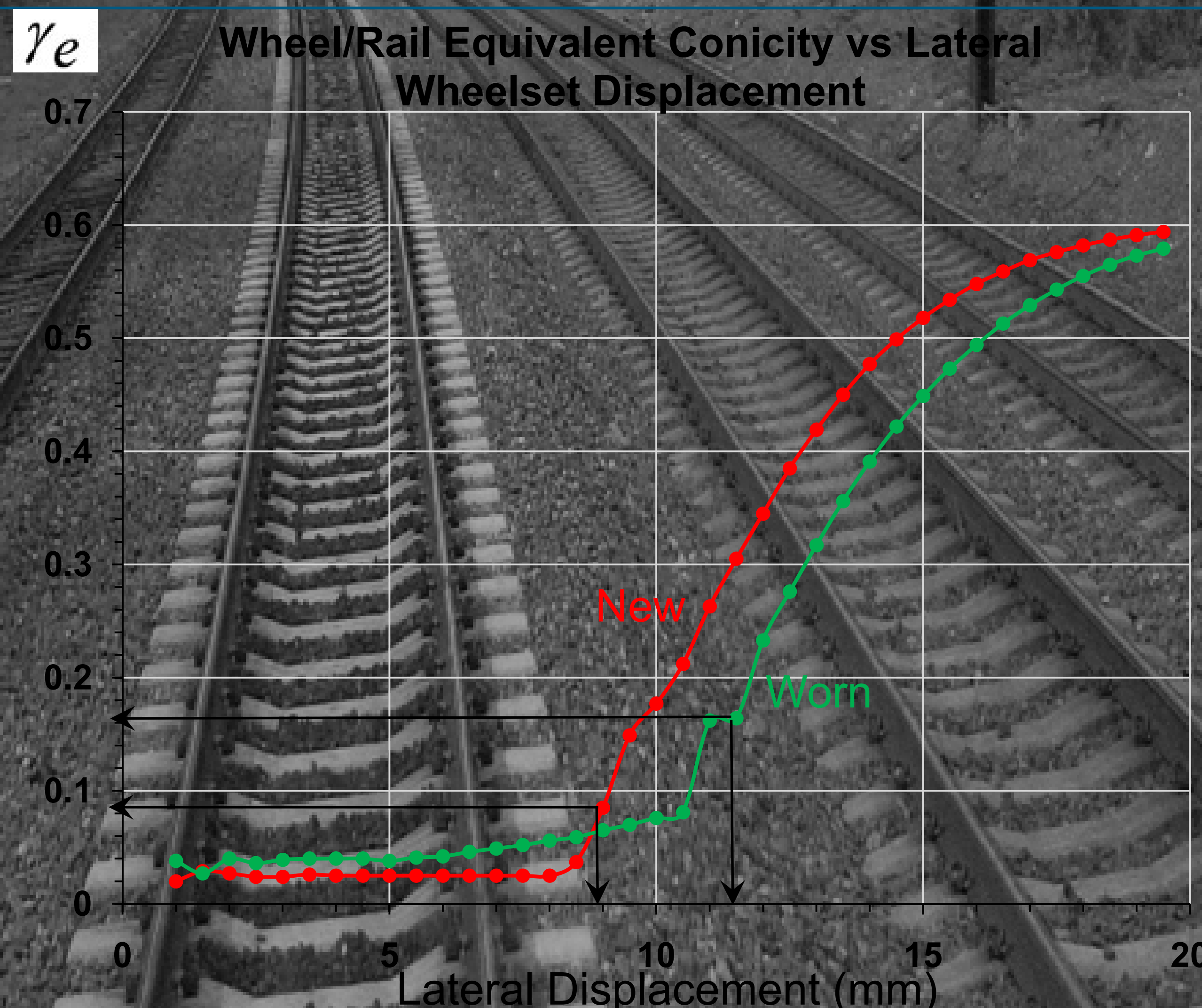
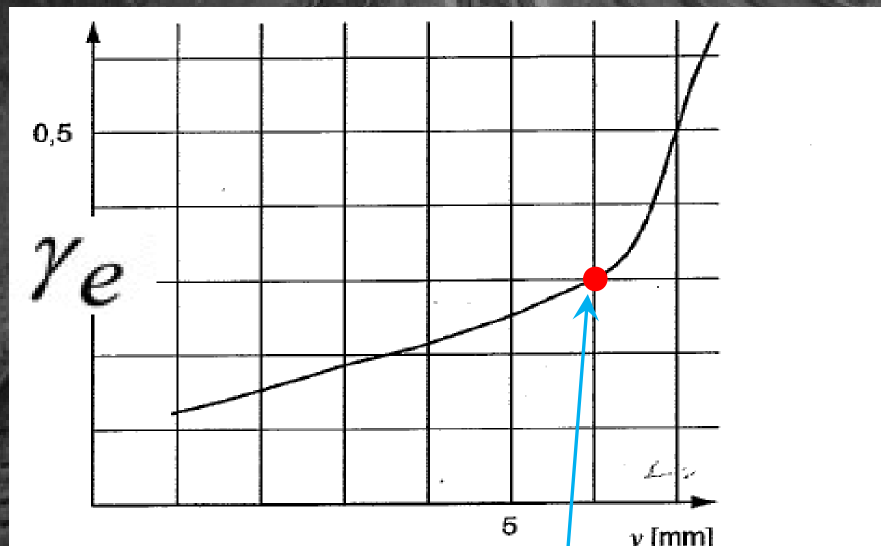
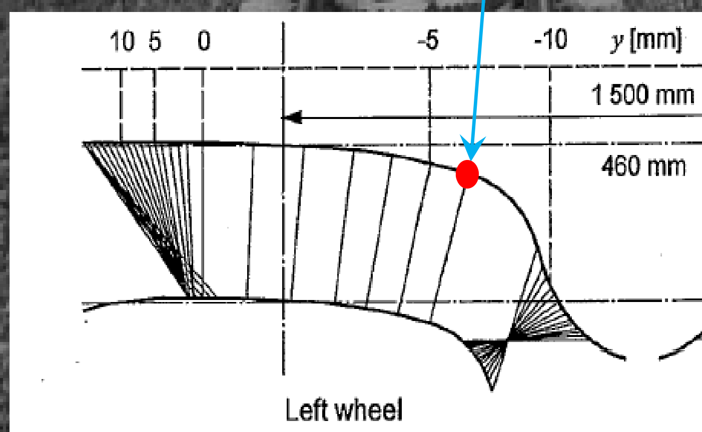
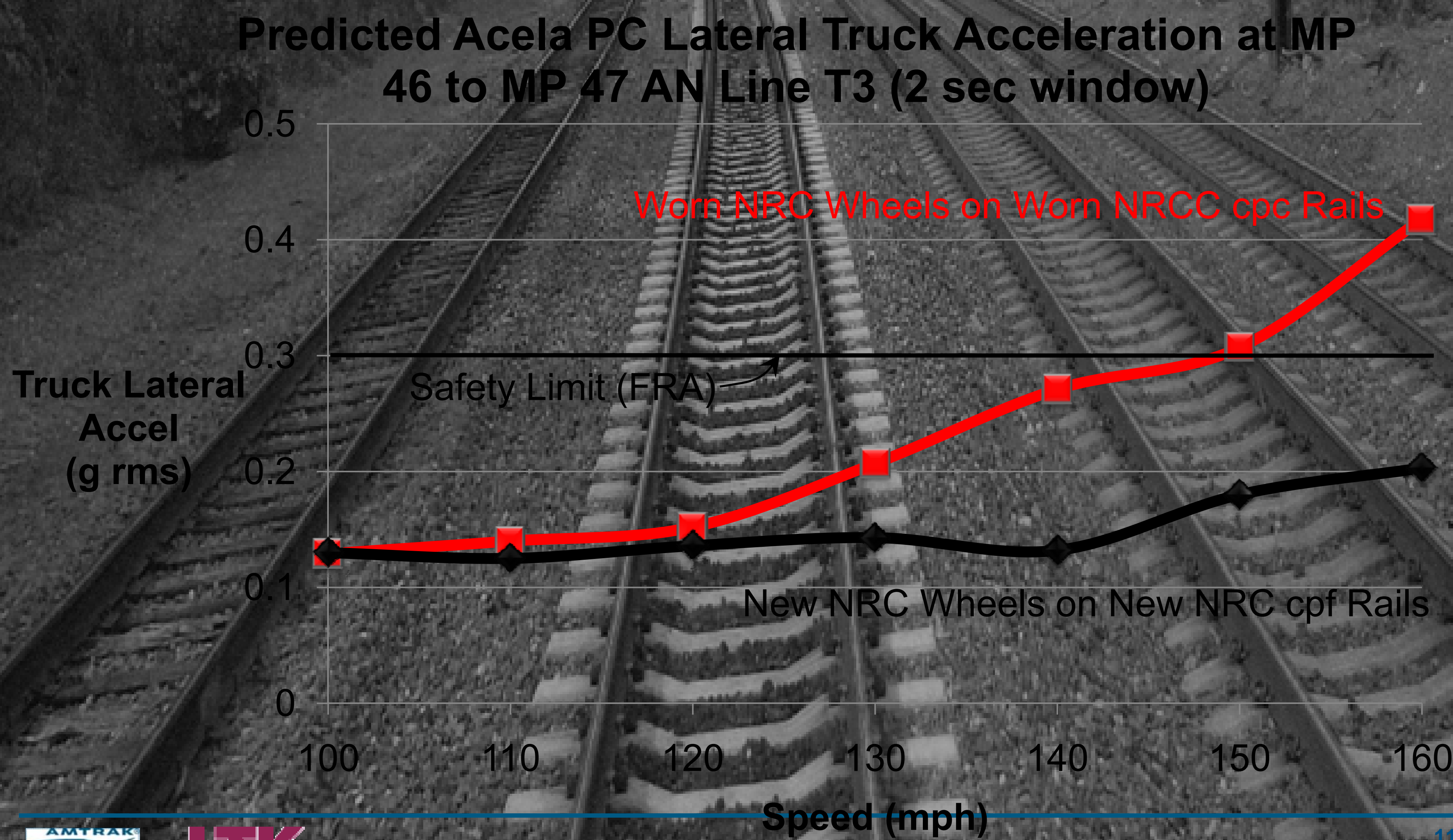


Equivalent Conicity with Wheel/Rail Contact Position

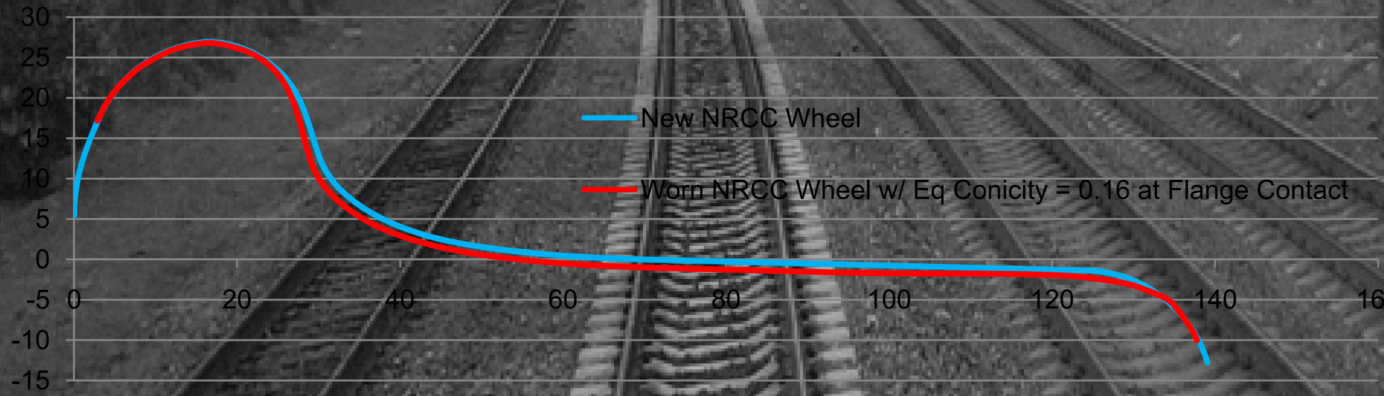


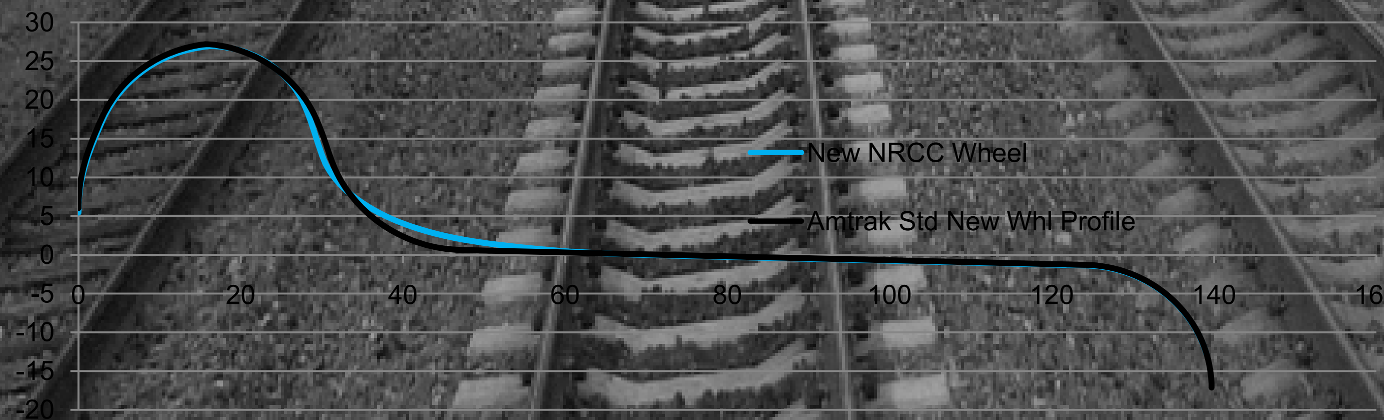


Improved Predictive Analysis from Understanding of Increasing Equivalent Conicity with Wheel/Rail Wear



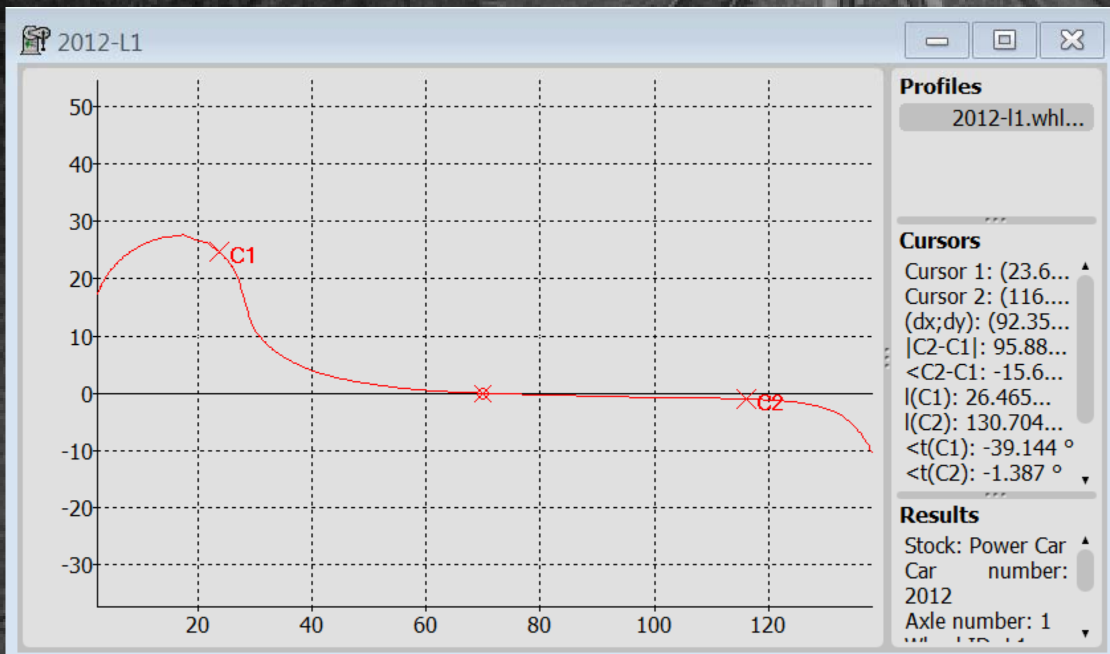
Acela Power Car is Sensitive to Relatively Small Increase in Equivalent Conicity with Wear





<u>Automated program needed to monitor increasing equivalent conicity with wheel/rail wear.</u>

Accurate measurements of wheel and rail profiles are critical for this analysis

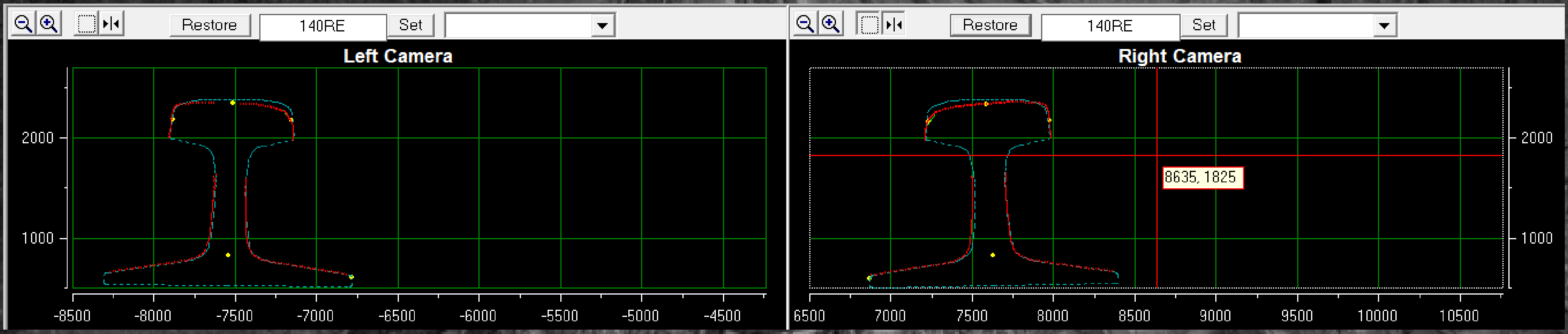


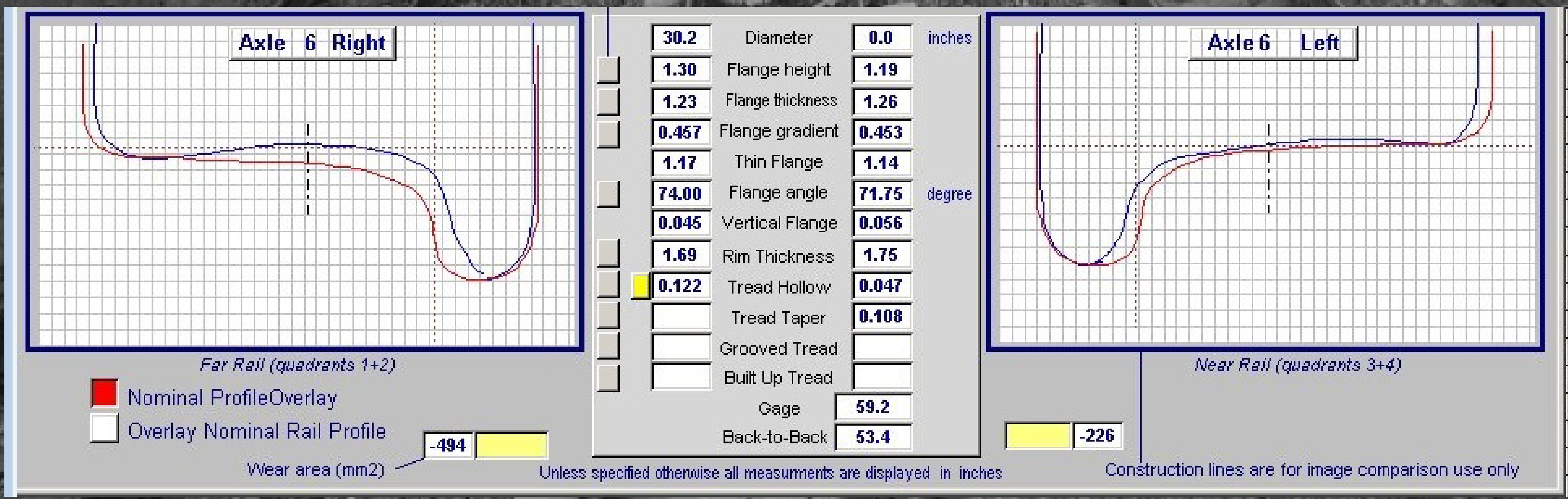
MiniProf data not feasible for an automated analysis

Automated measurements are necessary for a comprehensive monitoring program

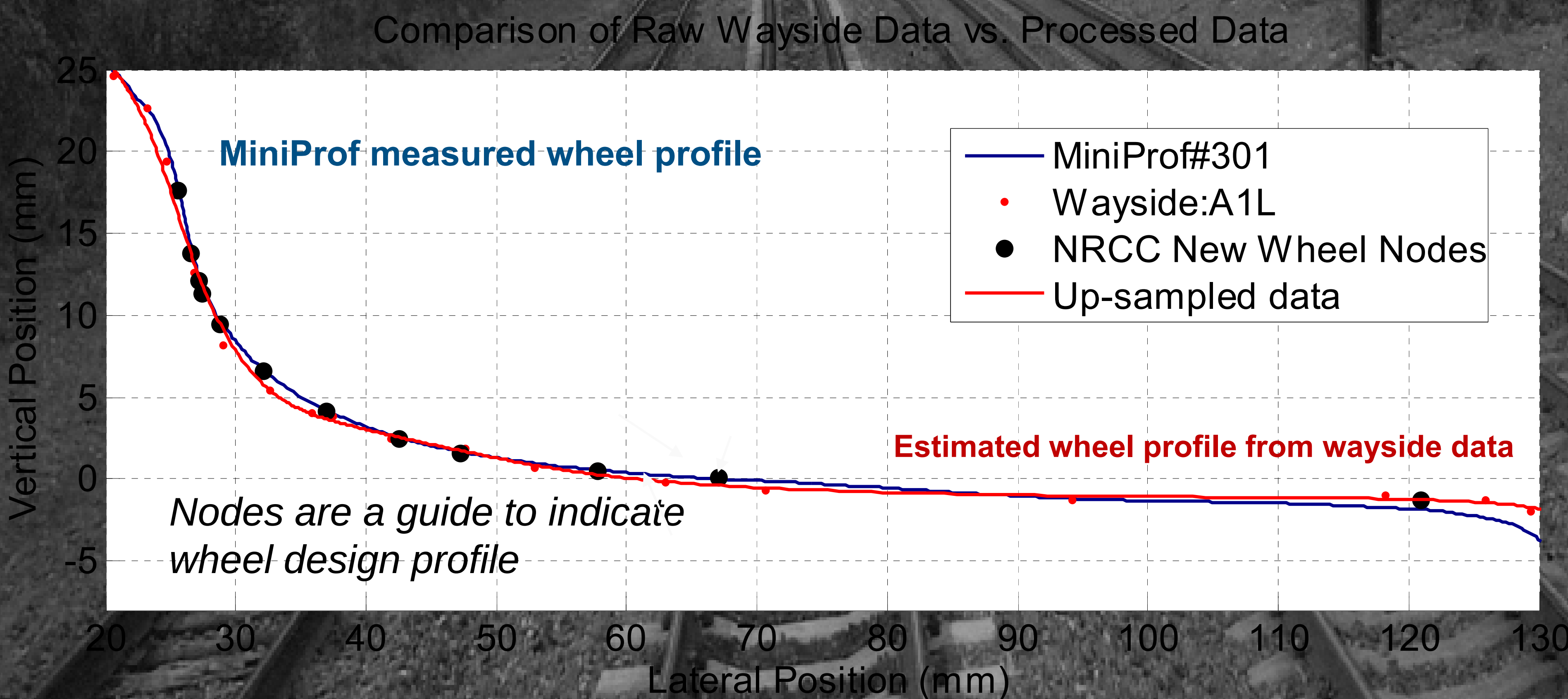
AMTRAK LTK

Currently, Amtrak employs wayside and geocar-mounted laser measurement systems for collecting profile data, but fidelity is not high enough for dynamics modeling software



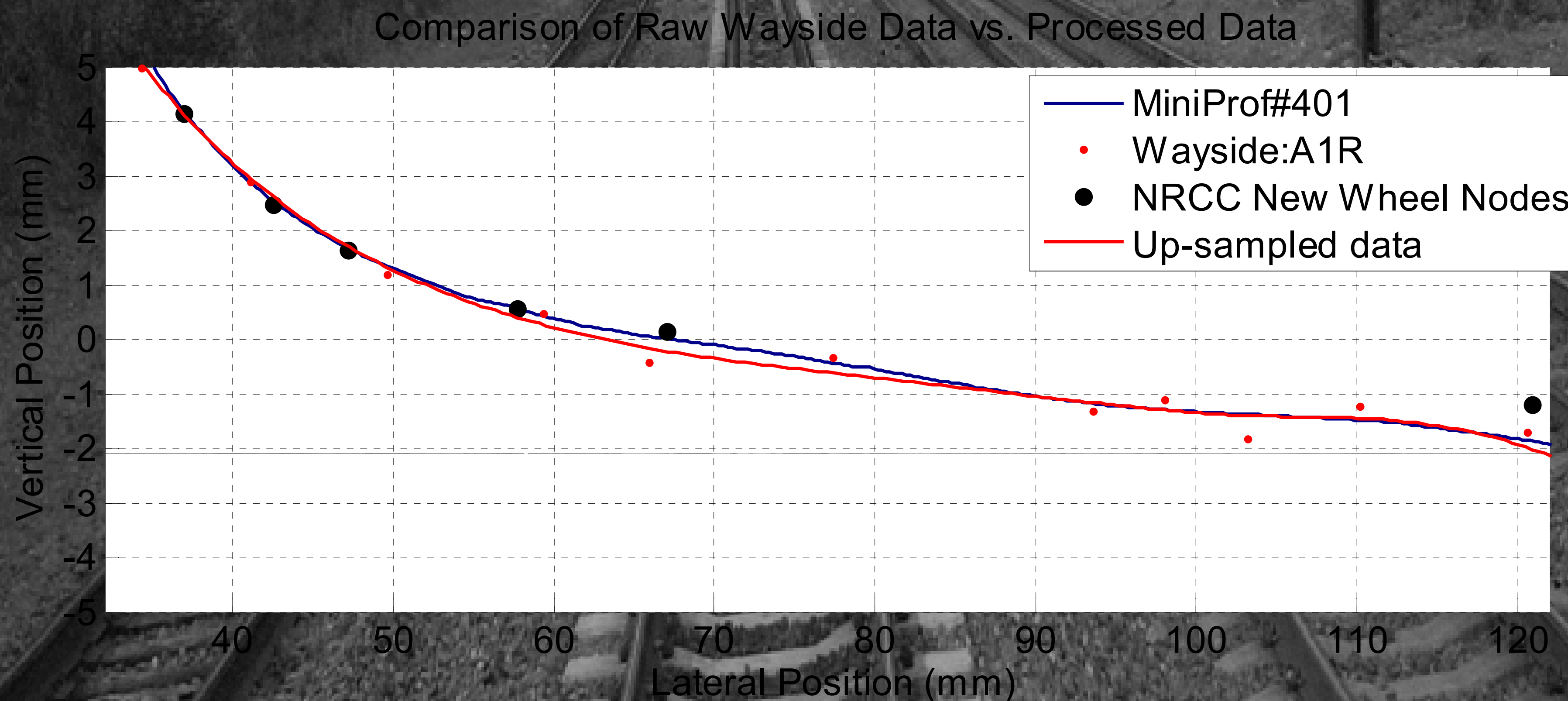


To make calculations possible, laser measurements must be up-sampled and filtered in order to be usable



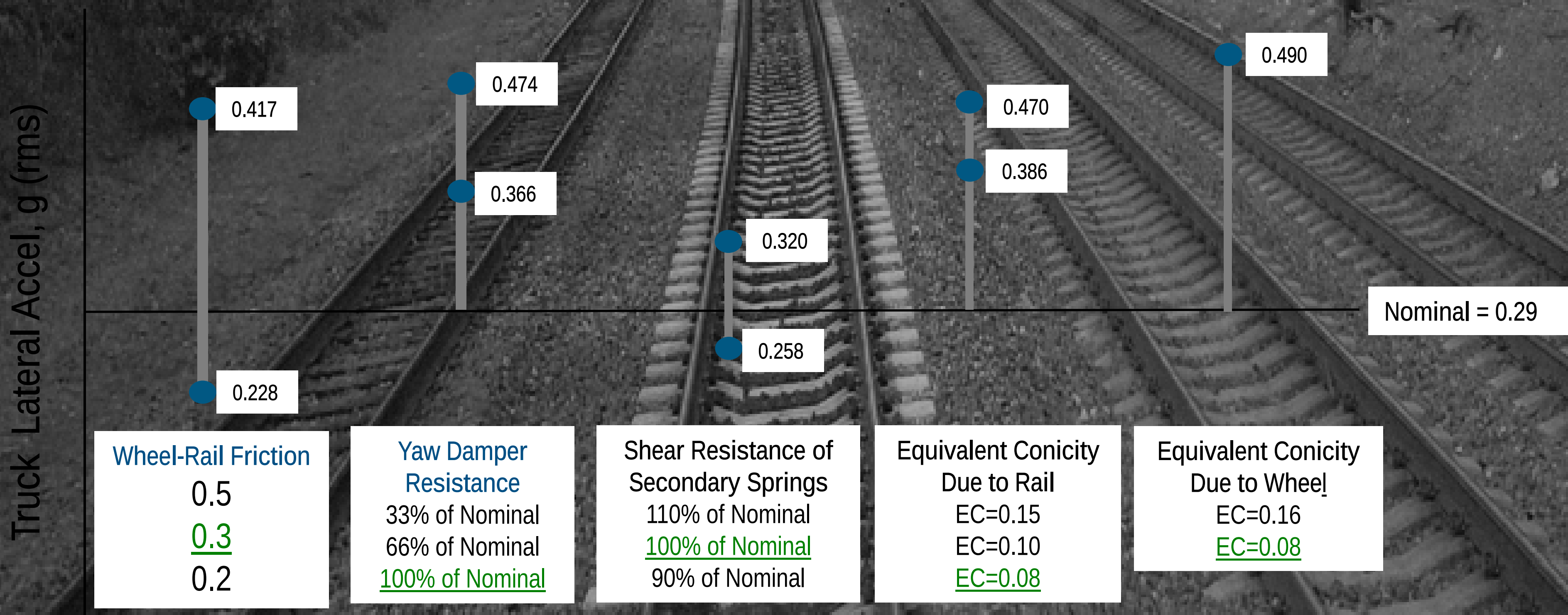
Data from the laser measurement systems is post-processed within Matlab®

Although improving measurement accuracy is desirable, processing data from current measuring equipment presents a path forward to automate this monitoring program



Wayside equipment measurement error can exceed 0.050" (>1mm), and is affected by vehicle speed past the detectors

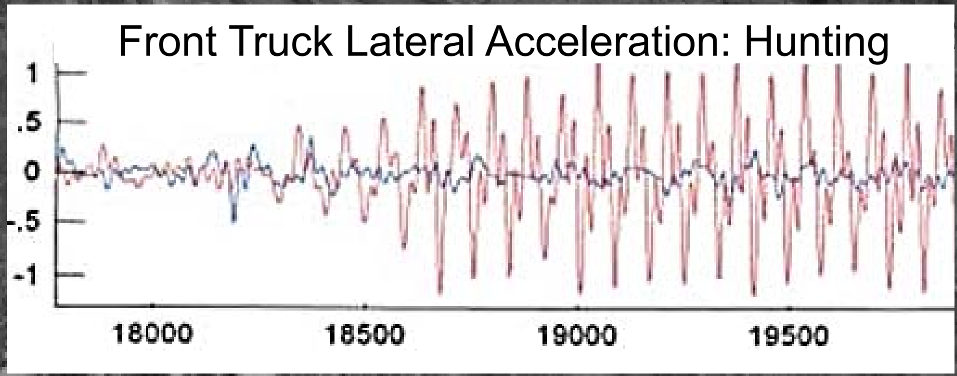
Sensitivity analyses have demonstrated the influence of various parameters upon truck hunting propensity

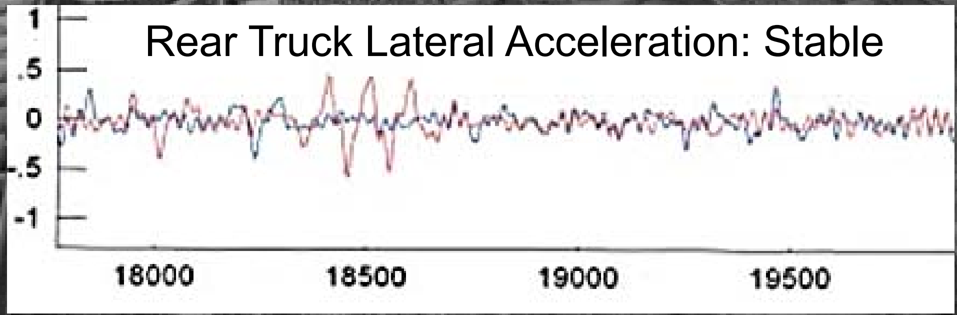


(Nominal Case is underlined)

Conclusions

- Wheel/Rail equivalent conicity has large effect upon Acela PC truck hunting at highest speeds



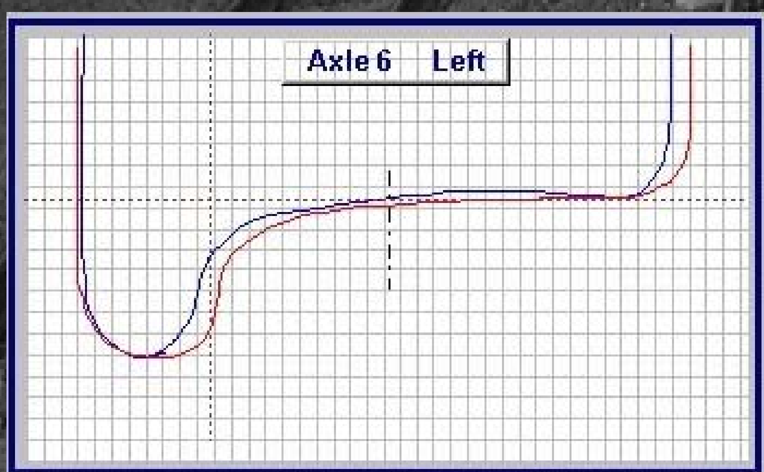


- Program for automated monitoring of wheel and rail profiles for changes in equivalent conicity is being developed using current measuring equipment, but requires postprocessing with Matlab® engineering tools

Conclusions

- While improved profile measurement systems would provide reduced simulation error, the current system does provide a path forward to perform this analysis

- Adequacy of existing automated methods for monitoring wheel/rail profiles is being assessed



Current

Alternative

QUESTIONS?

Thank you for your attention!