OFFICE OF RESEARCH & DEVELOPMENT

2012 R&D REVIEW

Rail Seat Abrasion

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Federal Railroad Administration

Program Area & Risk Matrix

Rail Seat Abrasion

Program Areas \ Risk Factors	Trespass	Grade Crossing	Derailment	Train Collision	All Other Safety Hazards
Railroad Systems Issues					
Human Factors					
Track & Structures			X		
Track & Train Interaction					
Facilities & Equipment					
Rolling Stock & Components					
Hazardous Materials					
Train Occupant Protection					
Train Control & Communications					
Grade Crossings & Trespass					

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Acknowledgements & Stakeholders

Acknowledgements

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- John Choros, Volpe

Stakeholders & Project Partner(s)

- Mark Austin, CSX
- Seth Ogan, BNSF

Introduction

- Rail Seat Abrasion (RSA) is loss of material in the rail seat on concrete ties.
  - Loss of clip preload
  - Loss of proper rail cant
  - Gage widening

- Working Theory: Deep, wedge shaped abrasion can be caused by severe track geometry deviations. These deviations cause wheel rail forces that produce high stresses in the rail seat.

Objectives

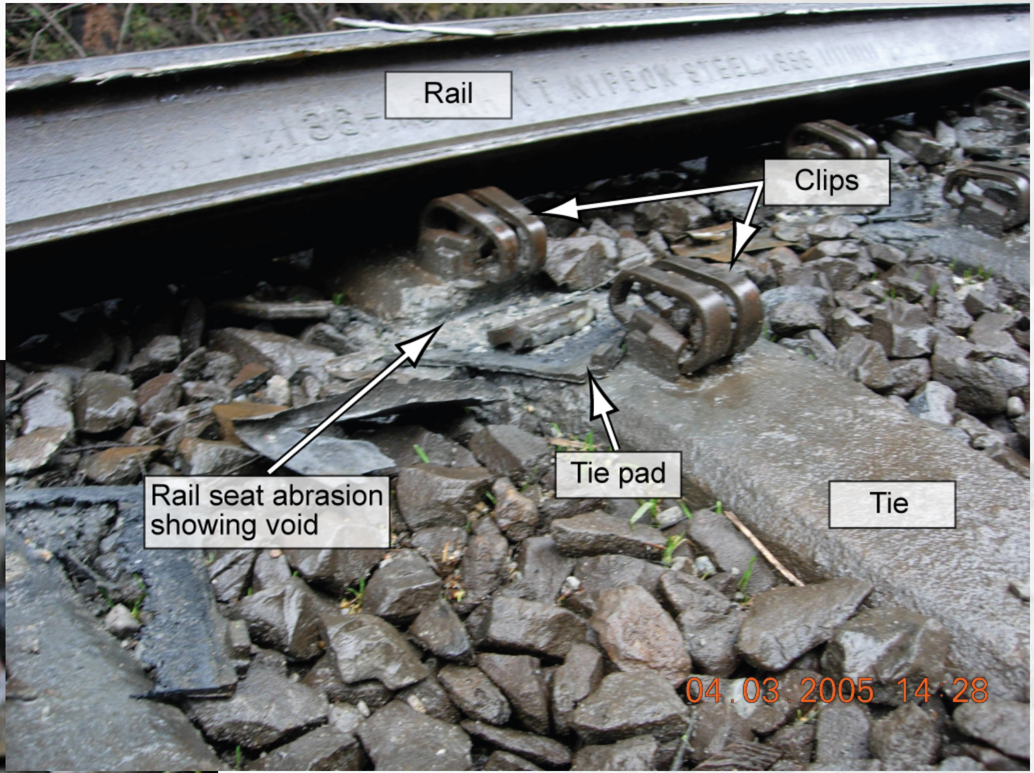
- Phase I of the project had three main objectives:
  - Measure RSA at selected revenue service sites to determine severity and extent of RSA, depth and patterns of RSA, and track geometry.
  - Use the field measurements as input to NUCARS®[1] simulations to determine track features and locations where vehicle performance was expected to introduce high lateral loads into the track.
  - Identify potential track geometry features for use in a future test zone on the Facility for Accelerated Service Testing (FAST) High Tonnage Loop to study RSA in a more controlled environment

- Concurrently, results were provided to the Federal Railroad Administration (FRA) and Volpe to support their efforts in developing RSA predictive modeling tools.

1. *NUCARS® is a registered trademark of Transportation Technology Center, Inc.*

Motivation for Project

- Home Valley, Washington, Derailment
- Sprague, Washington, Derailment
- "…attributed to excessive concrete crosstie abrasion, which allowed the outer rail to rotate outward and create a wide gage track condition."



Rosenker, Sumwalt, Hersman, Higgins. Railroad Accident Brief NTSB/RAB-06/03, National Transportation Safety Board, Washington D.C., 10/18/2006,

Method

- Work with Railroad partners to identify areas where rails would be removed from concrete ties for maintenance.
- Do a pre-inspection trip to survey the condition at the site and measure rail profiles.
- Obtain track geometry measurements from the site.
- Take measurements in coordination with the railroad maintenance work.
- Use track geometry to perform NUCARS® simulations of inspected sites.
- Correlate and plot simulation results together with the inspection results.

Method

- Field Survey Measurement Approach
  - RSA cannot be measured without removing the rail.

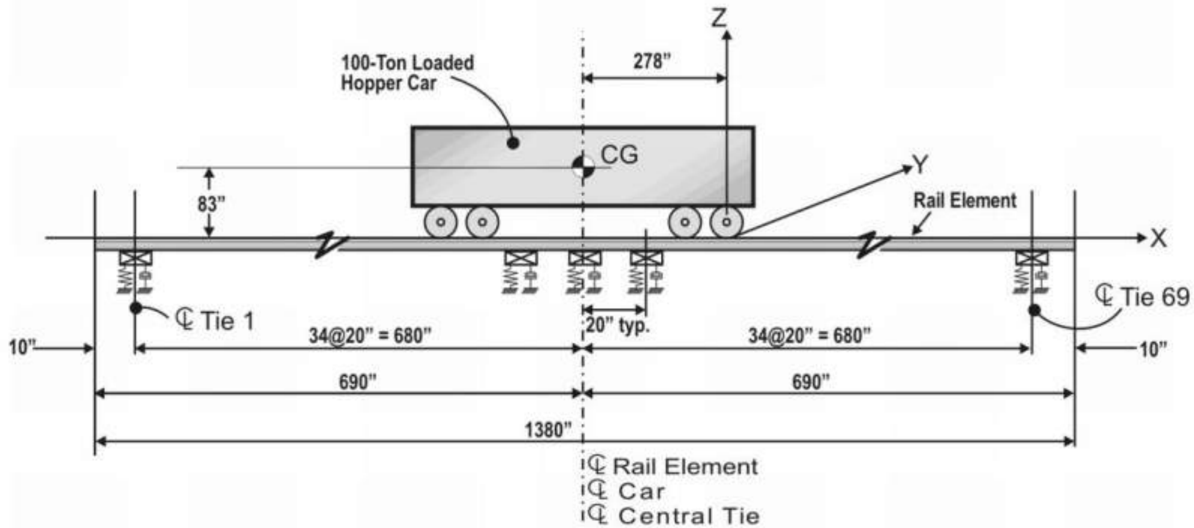
- For this reason measurements were performed during rail replacements and rail seat repairs.

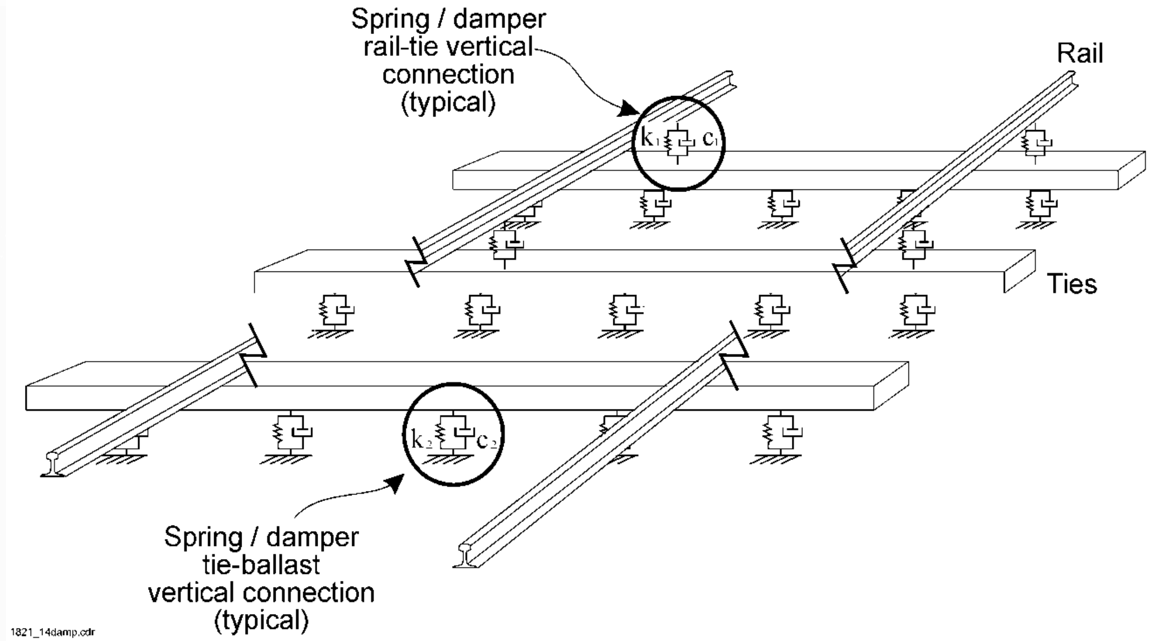
Method - Measurements

- Rail was declipped, swung out of the way, and railroad personnel cleaned old pads off of the rail seat.
- When this was finished the rail seats could be measured.
- The team replacing pads followed only a short distance behind leaving a limited time for measurements.

Method - NUCARS® Simulations

- Track geometry from the railroads and from the FRA DOTX 218 Car was used as input to simulations
- Included a track model so the forces between the rail and tie could be examined
- Loaded 100 ton 4 axle freight car, base case assumed one wheel profile and dry rail (μ=0.4)

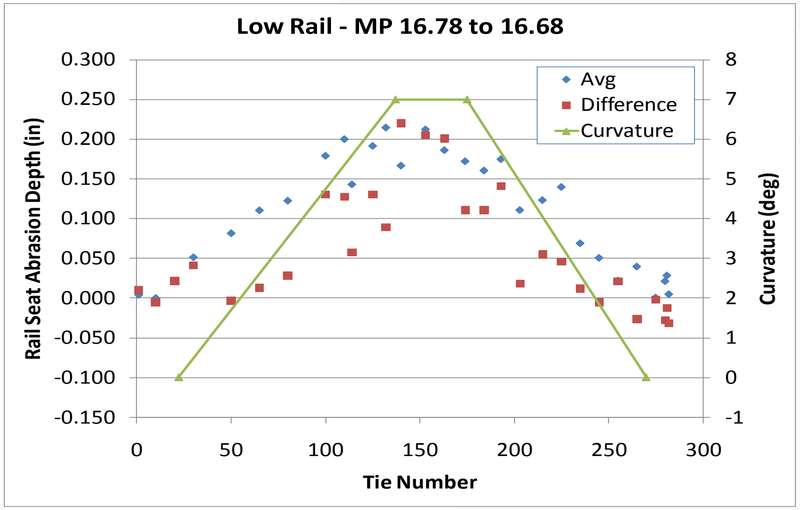


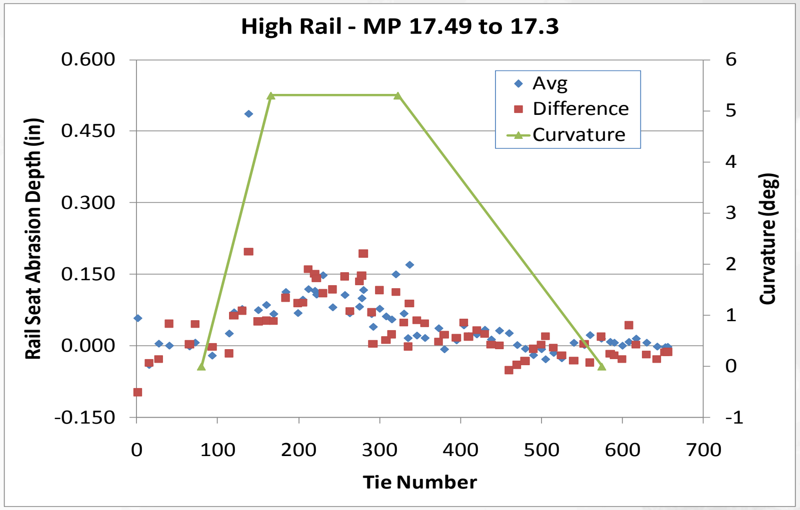


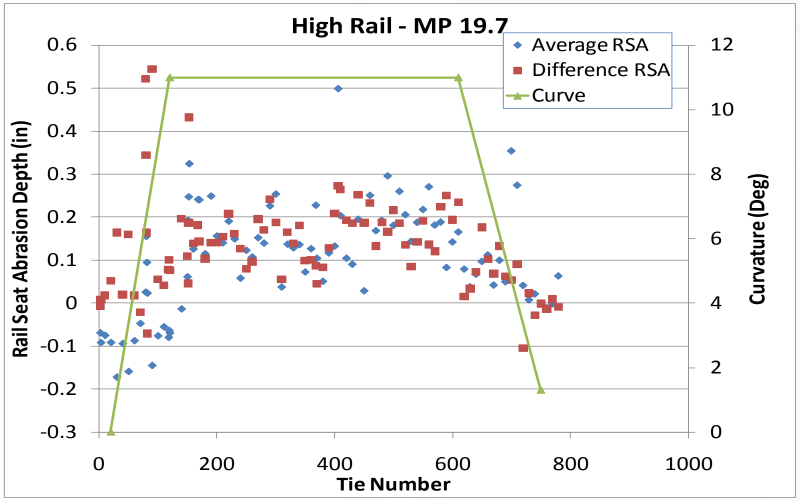
Results – Measurement Summary

- Three sites were inspected, total of 16 curves
- The CSX site in West Virginia had the highest rainfall, the tightest curvature, and the most abrasion
- The BNSF sites in Needles California and Alliance Nebraska had low rainfall, low curvature, and little abrasion – one curve at Needles showed abrasion onset
- Where abrasion was found, the pattern followed the change in curvature
- No localized track geometry features were correlated to areas of higher abrasion
- The following slides show examples of the inspection and simulation data

Results: CSX – significant abrasion





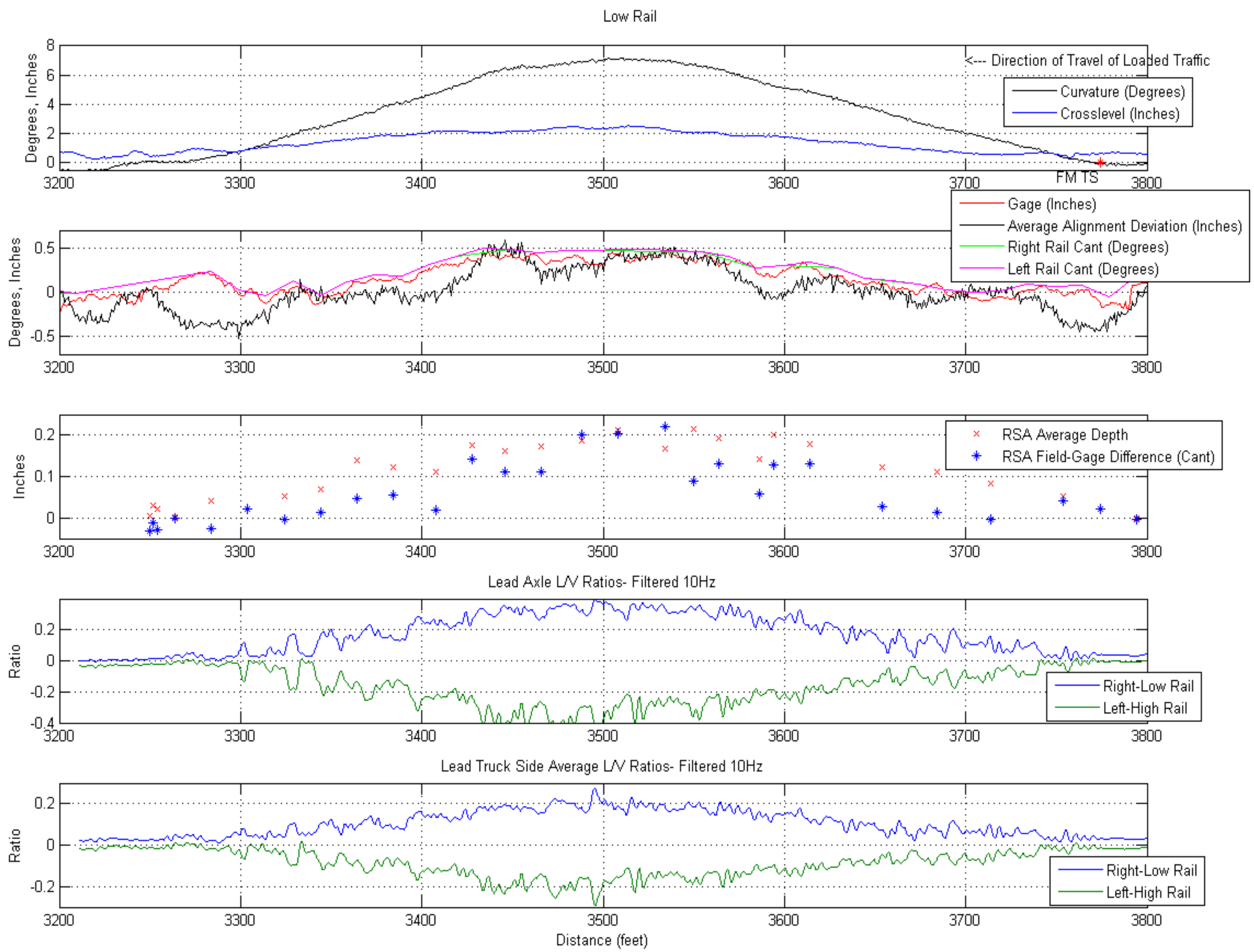


- These 3 curves were measured with manual gage
- An automatic system used initially had much more scatter than manual gage
  - See first 208 ties of 19.7

Avg = Average of measurements taken on field and gage side of rail seat.
Difference = Average of measurements on the field side minus the average of measurements on the gage side of the rail seat.
Positive = rail rolled out.

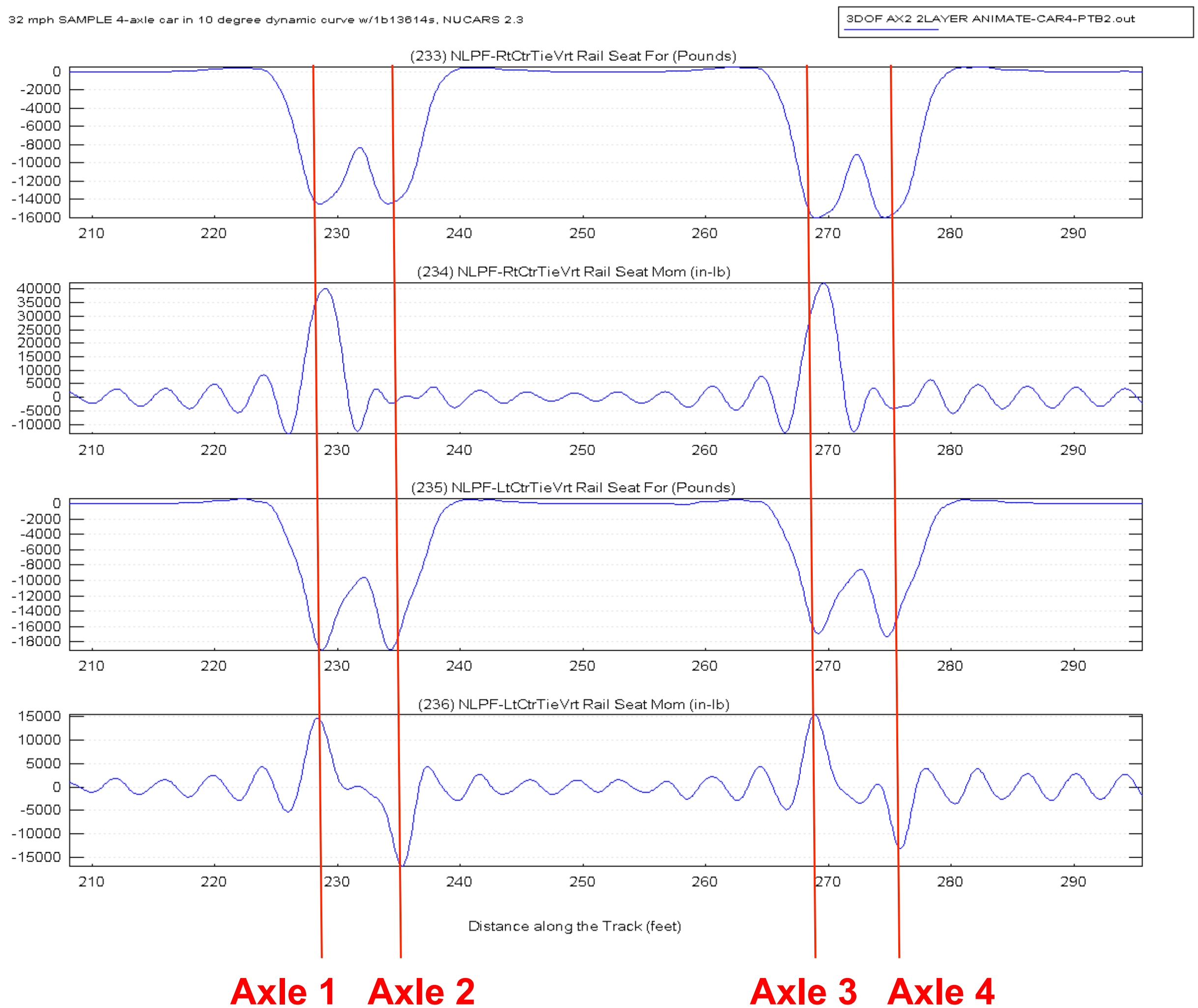
Results – CSX MP16

- Sample results for the CSX site. Curve at MP16 on the Coal River Subdivision near St. Albans, WV
- Simulation L/V results generally match the pattern of abrasion
- No distinct peaks in track geometry, lateral force or abrasion to indicate localized geometry induced abrasion



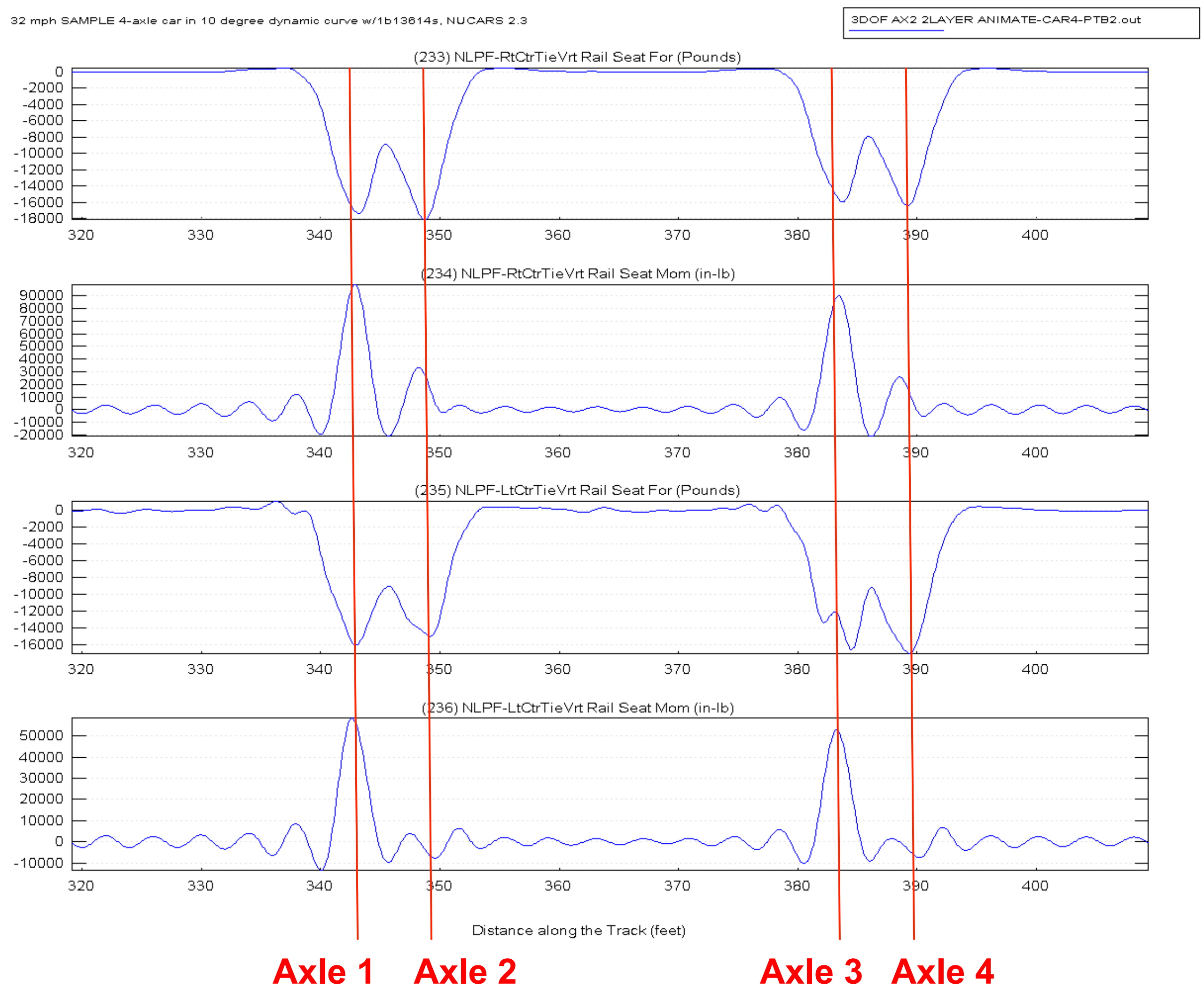
Results - CSX Simulations

- Simulation data shows the load and moment between the rail and crosstie as the axles of a car pass over it.
- Negative forces indicate compression of the rail seat. Positive moments are toward the field side.
- These forces are for a tie in the entry spiral



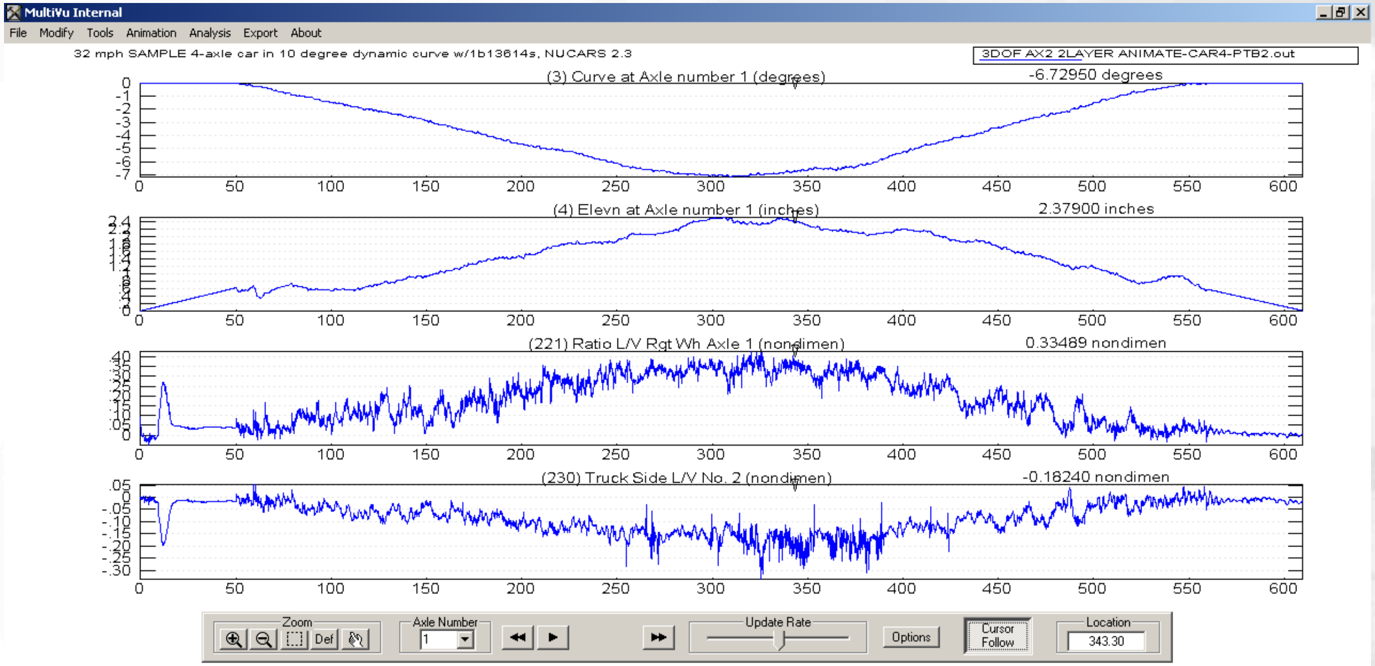
Results – CSX Simulations

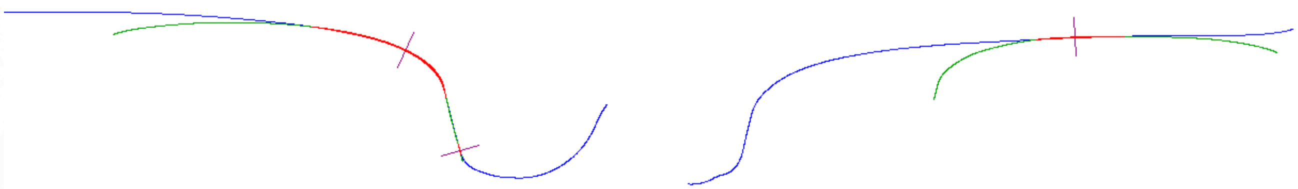
- These forces are for the exit spiral in the simulation.
- Note that at this location both axles of a truck cause positive moments on the rail seat.



Results – CSX Simulations

- Wheel-rail contact condition on axle 1
- Contact in the flange root and a second point of contact at the flange tip.





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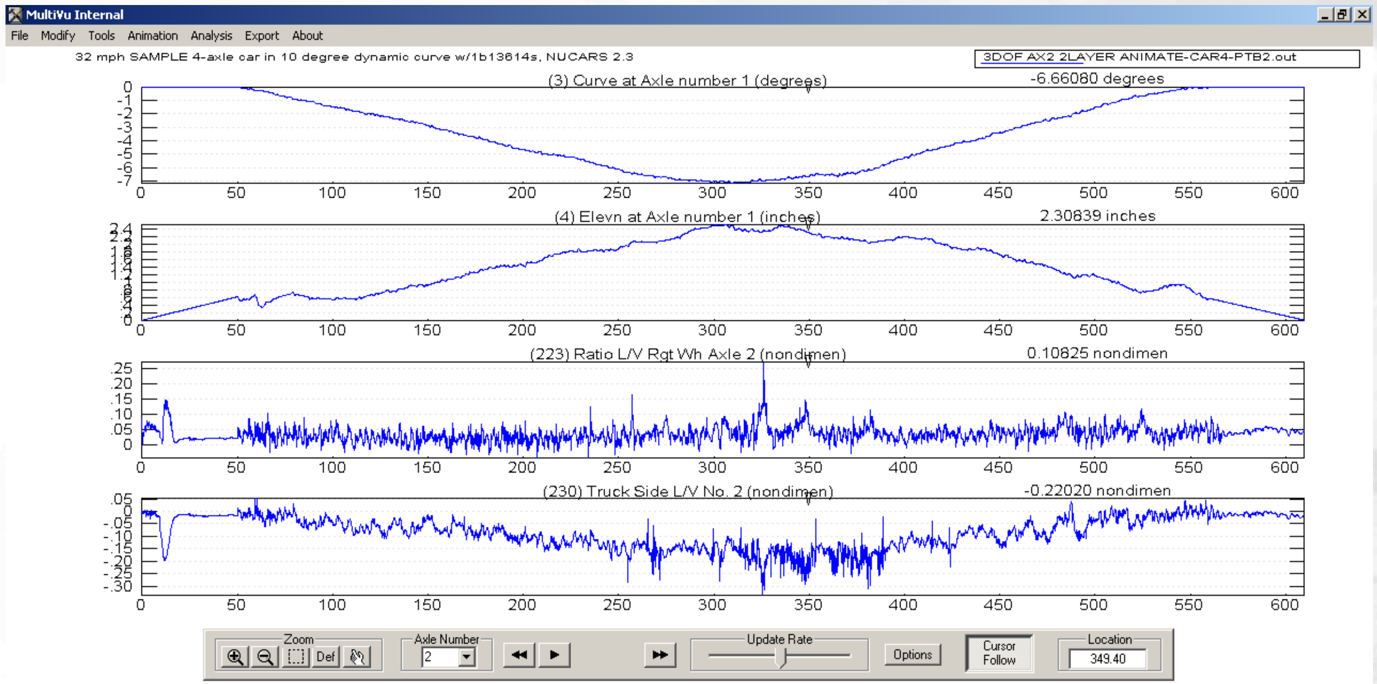
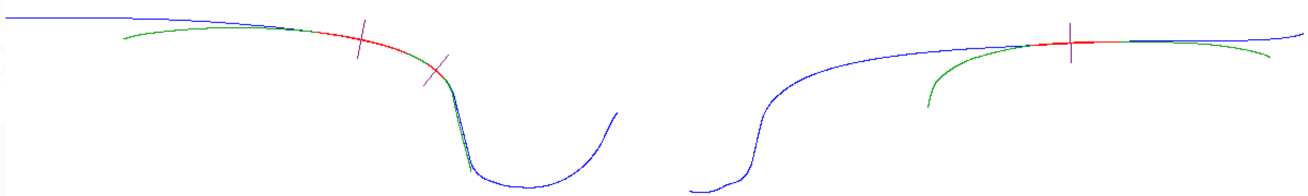
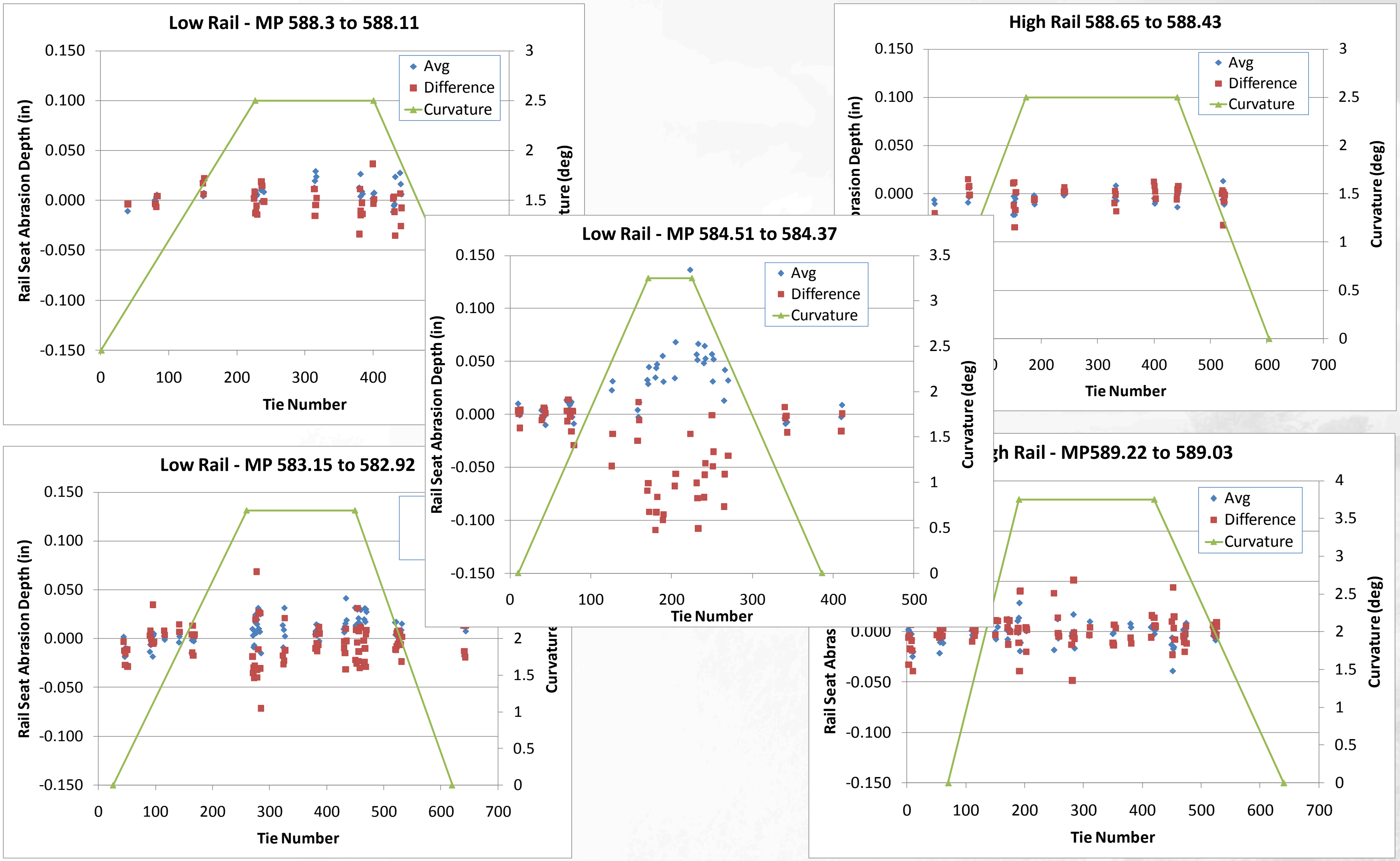
Results – CSX Simulations

- Wheel-rail contact condition on axle 2
- Contact is only in the flange root.
- The location of the contact points affects the moment transferred to the rail seat.





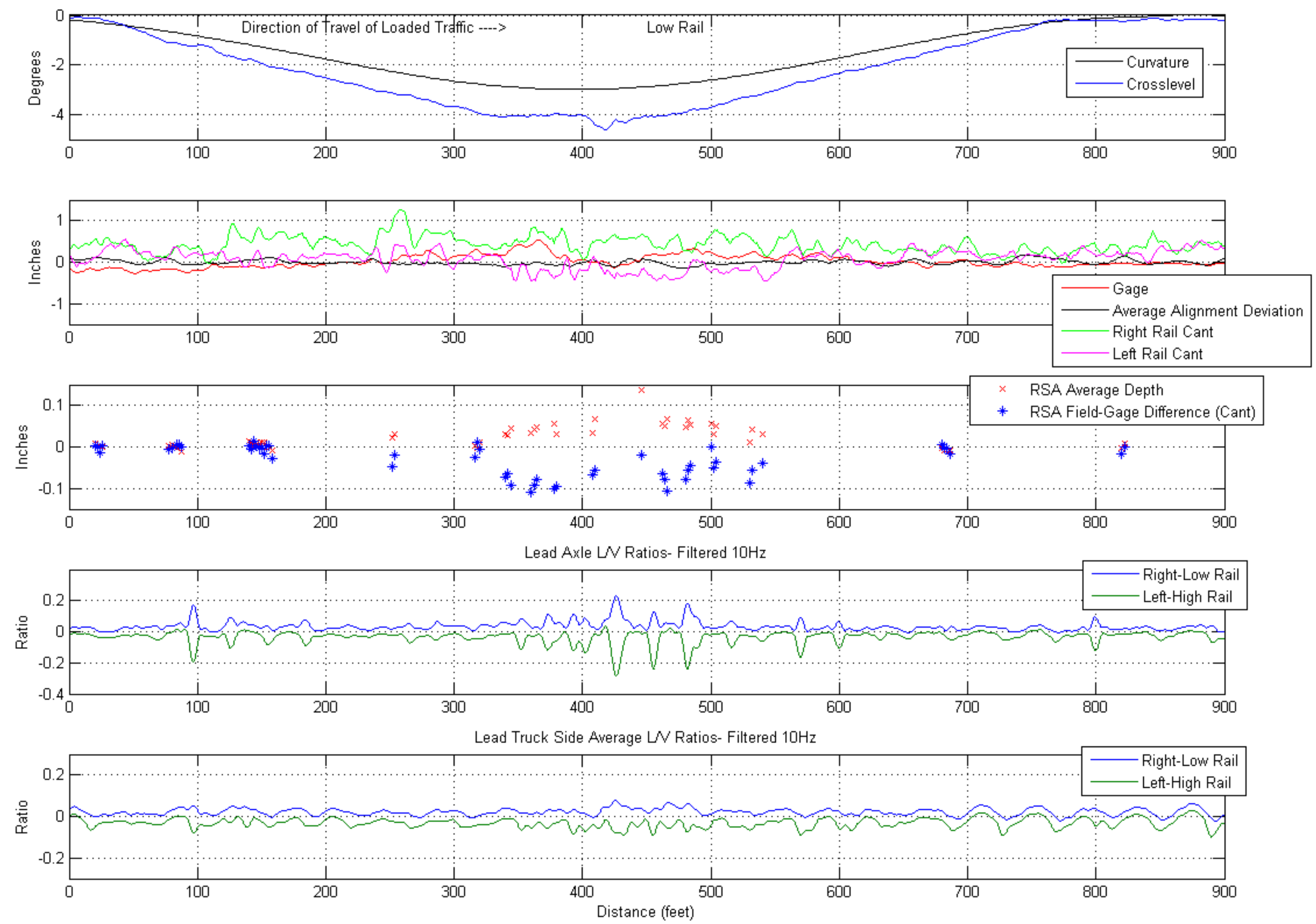
Results: Needles- very little abrasion



Avg = Average of measurements taken on field and gage side of rail seat.
Difference = Average of measurements on the field side minus the average of measurements on the gage side of the rail seat.
Positive = rail rolled out.

Results – BNSF Needles MP584

- Sample results for the only BNSF site with significant abrasion. Curve at MP584 near Needles.
- Simulation L/V results much lower than CSX but generally match the pattern of abrasion
- No distinct peaks in track geometry, lateral force or abrasion to indicate localized geometry induced abrasion

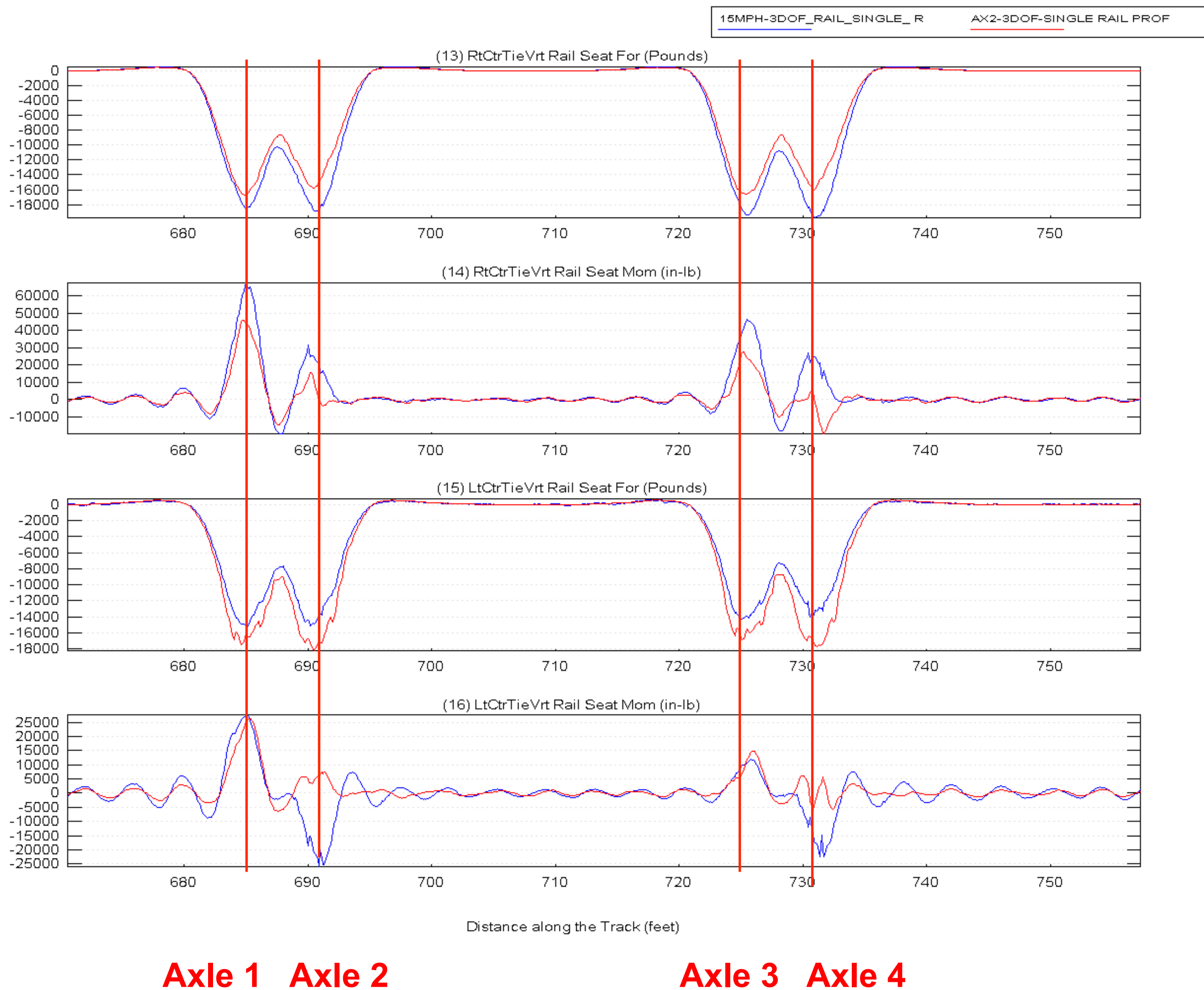


Results – BNSF MP584 Simulations

Effect of speed on rail seat forces

- East and west bound traffic at site have two distinct operational speeds at site:
- Red = 50 mph
- Blue = 15 mph

- Simulation is for 4-axle 100 ton loaded freight car. General traffic at site is mixed, including large amount of intermodal multi-platform cars, with smaller amount of heavy haul.



Results – BNSF MP584 Simulations
Effect of W/R friction on simulation results

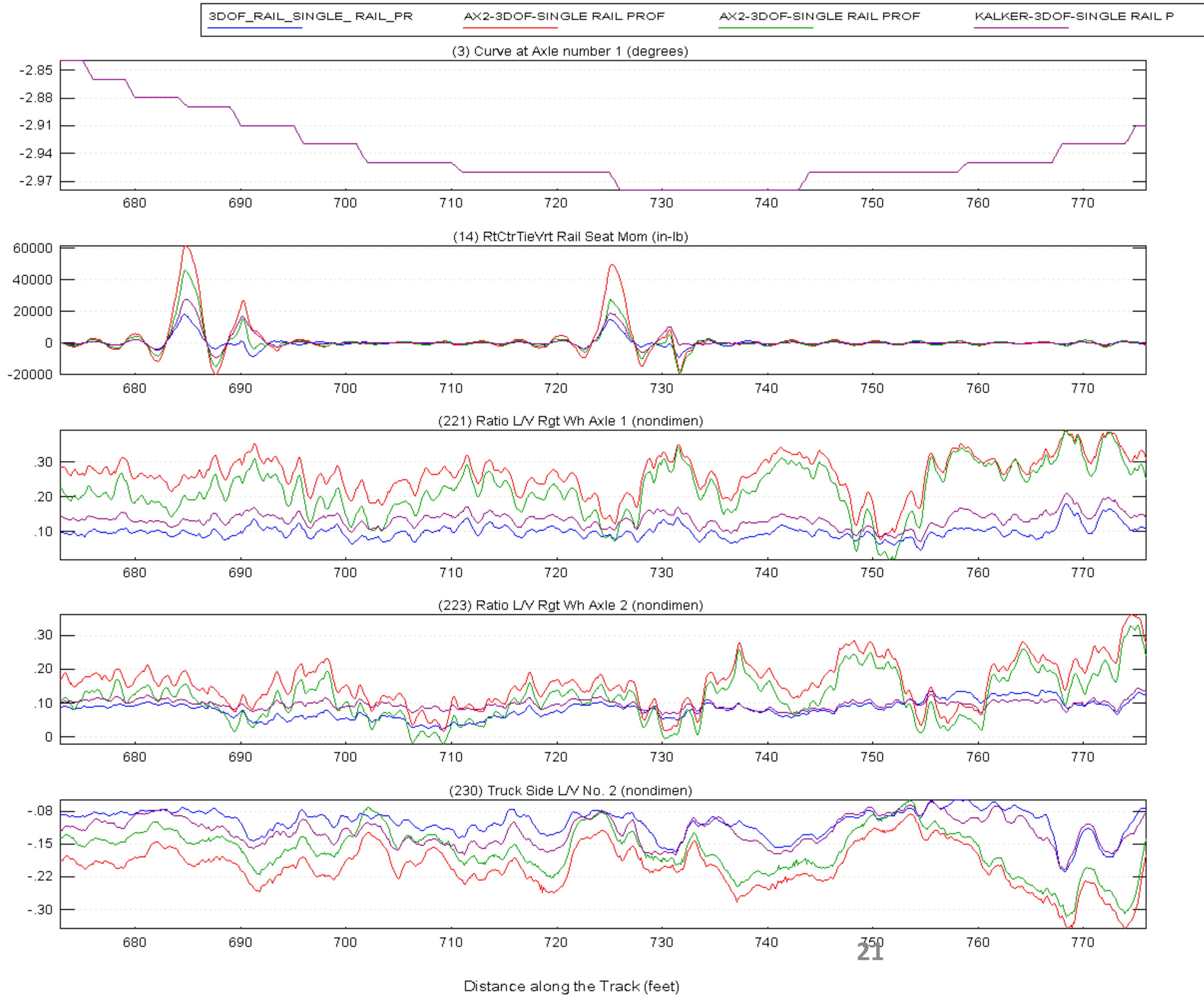
Evidence of lubrication found at site. However friction coefficient and type of lubricant was not measured.

Green = dry rails

Red = gauge face lubrication

Blue = TOR friction modifier

Purple = Gauge face lubrication and TOR friction modifier



Conclusions from Phase I

- Sixteen curves on three different railroads were inspected and analyzed for Rail Seat Abrasion (RSA)
  - Where RSA was found, the severity appeared to be generally related to track curvature
- Simulation results generally match the rail seat abrasion patterns that were measured
- Local traffic, operational and lubrication practices can affect results
  - May need to simulate local conditions in greater detail

Conclusions from Phase I, continued

- A hypothesis that a particular track geometry feature (such as down and out perturbations) is a trigger for the development of RSA could not be confirmed from the limited number of sites where RSA was found
- Measurement methods probably affected this result
  - Access was limited to where track work was being done
  - Need accurate automated tools to speed up measurements and avoid skipping ties
  - Need to measure wheel and rail profiles
  - Need to measure rail friction conditions
  - Need to measure pad and clip details
  - Need space curve track geometry for model input

Proposed Phase II Work

- Use a previously measured down and out perturbation as a starting point, use modeling to identify a track geometry deviation expected to cause Rail Seat Abrasion

- Install this perturbation at FAST where it can be carefully monitored
  - Gage, crosslevel, rail cant, gage restraint with the LTLF, wayside forces, and instrumented freight car