Instrumented Wheel-set Measurements and Simulations Through a High Speed Turnout on Amtrak's Northeast Corridor

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Next Generation Turnout Design

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- Amtrak's current designs based on older Secant or Tangential Geometry
- Seek new designs for increased speeds for "thru" and "diverging" routes while maintaining comfort and safety
- Improved designs sought for better curving performance in slower speed turnouts as well

Next Generation Turnout Design

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- Acela IWS and Carbody & Truck acceleration tests performed on diverging route thru 32.75 T.O.
  - Crossover at Davisville, Rhode Island chosen for tests installed in 1993
  - No special upgrading or maintenance performed
  - Trials at 10 MPH increments from 80 to 110 MPH
- Goal was to see how much “reserve” is in 32.75 T.O.
- IWS is required annually as part of current waiver process for HS operations per FRA
- IWS wheel/rail forces and acceleration measurements compared to modeling prediction

Measured IWS Wheel/Rail Forces and Carbody & Truck Accelerations in High Speed Turnout

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Wheel/Rail Force Ratio Safety Limits per FRA 213.333 and 60% Design Limits

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Wheel Rail Forces			
Parameter	Safety Limit	Design Limit	Filter Window
Single Wheel Vertical Load Ratio	≥ 0.15	≥ 0.24	5 feet
Single Wheel L/V Ratio	≤ 1.0	≤ 0.6	5 feet
Net Axle Lateral L/V Ratio	≤ 0.5	≤ 0.3	5 feet
Truck Side L/V Ratio	≤ 0.6	≤ 0.36	5 feet

Carbody Acceleration Safety Limits per FRA 213.333 and 60% Design Limits

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Carbody Accelerations		
Parameter	Safety Limit	Design Limit
Carbody Lateral (Transient)	≤ 0.65g peak-to-peak (passenger) ≤ 0.75g peak-to-peak (other) 1 second window excludes peaks < 50 milliseconds	≤ 0.39g peak-to-peak (passenger) ≤ 0.45g peak-to-peak (other) 1 second window excludes peaks < 50 milliseconds
Carbody Lateral (Sustained Oscillatory)	≤ 0.10g RMS_t (passenger) ≤ 0.12g RMS_t (other) 4 second window 4 seconds sustained	≤ 0.06g RMS_t (passenger) ≤ 0.072g RMS_t (other) 4 second window 4 seconds sustained

Carbody & Truck Acceleration Limits per FRA 213.333 and 60% Design Limits

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Carbody Accelerations		
Parameter	Safety Limit	Design Limit
Carbody Vertical (Transient)	≤ 1.0g peak-to-peak (all equipment) 1 second window excludes peaks < 50 milliseconds	≤ 0.6g peak-to-peak (all equipment) 1 second window excludes peaks < 50 milliseconds
Carbody Vertical (Sustained Oscillatory)	≤ 0.25g RMS_t (all equipment) 4 second window 4 seconds sustained	≤ 0.15g RMS_t (all equipment) 4 second window 4 seconds sustained
Truck Lateral Accelerations		
Truck Lateral Acceleration	≤ 0.30g RMS_t (all equipment) 2 second window 2 seconds sustained	≤ 0.18g RMS_t (all equipment) 2 second window 2 seconds sustained

Wheel/Rail Force Ratio: Maximum Measured vs. Limits per FRA 213.333

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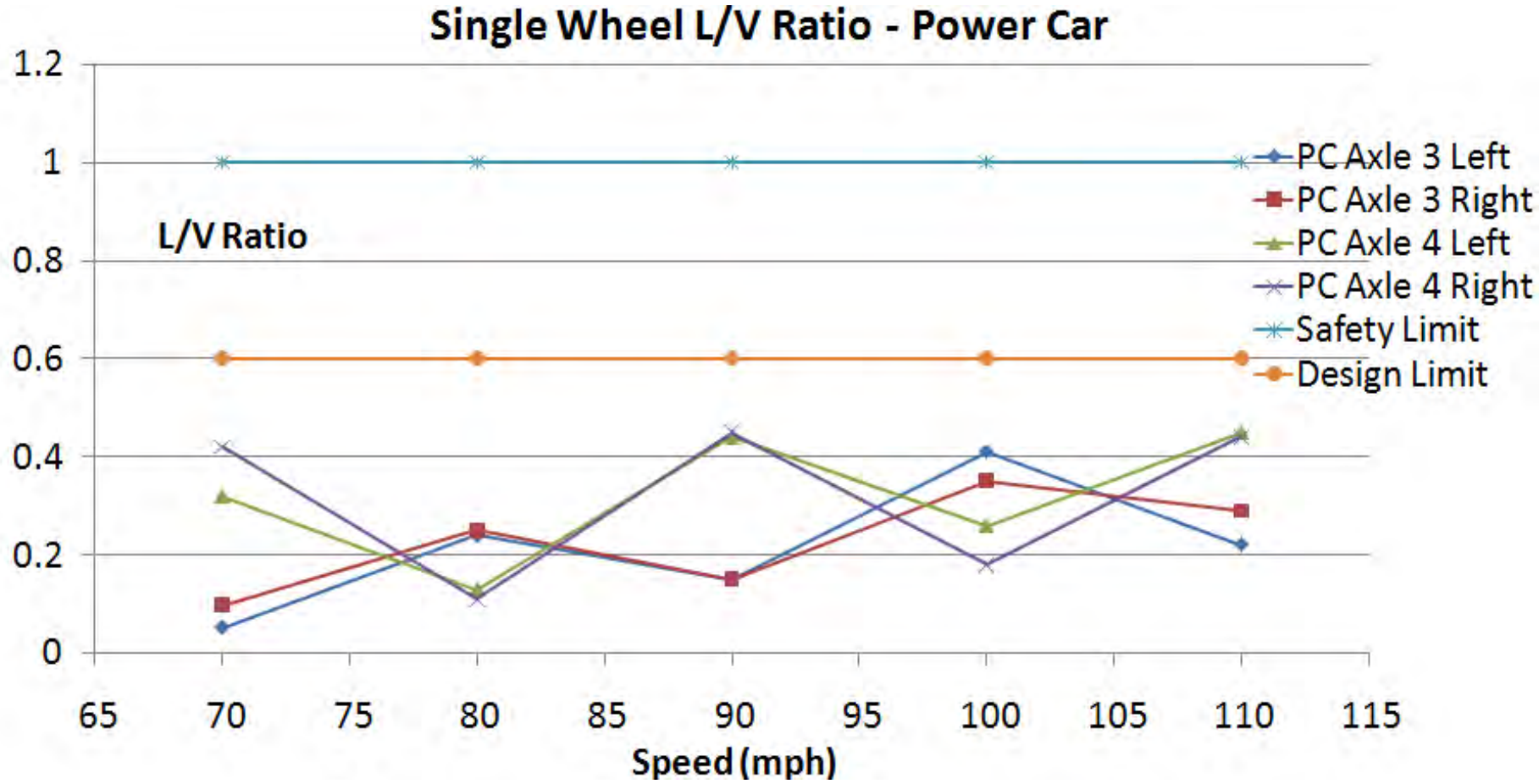

Wheel/Rail Force Ratio: Maximum Measured vs. Limits per FRA 213.333

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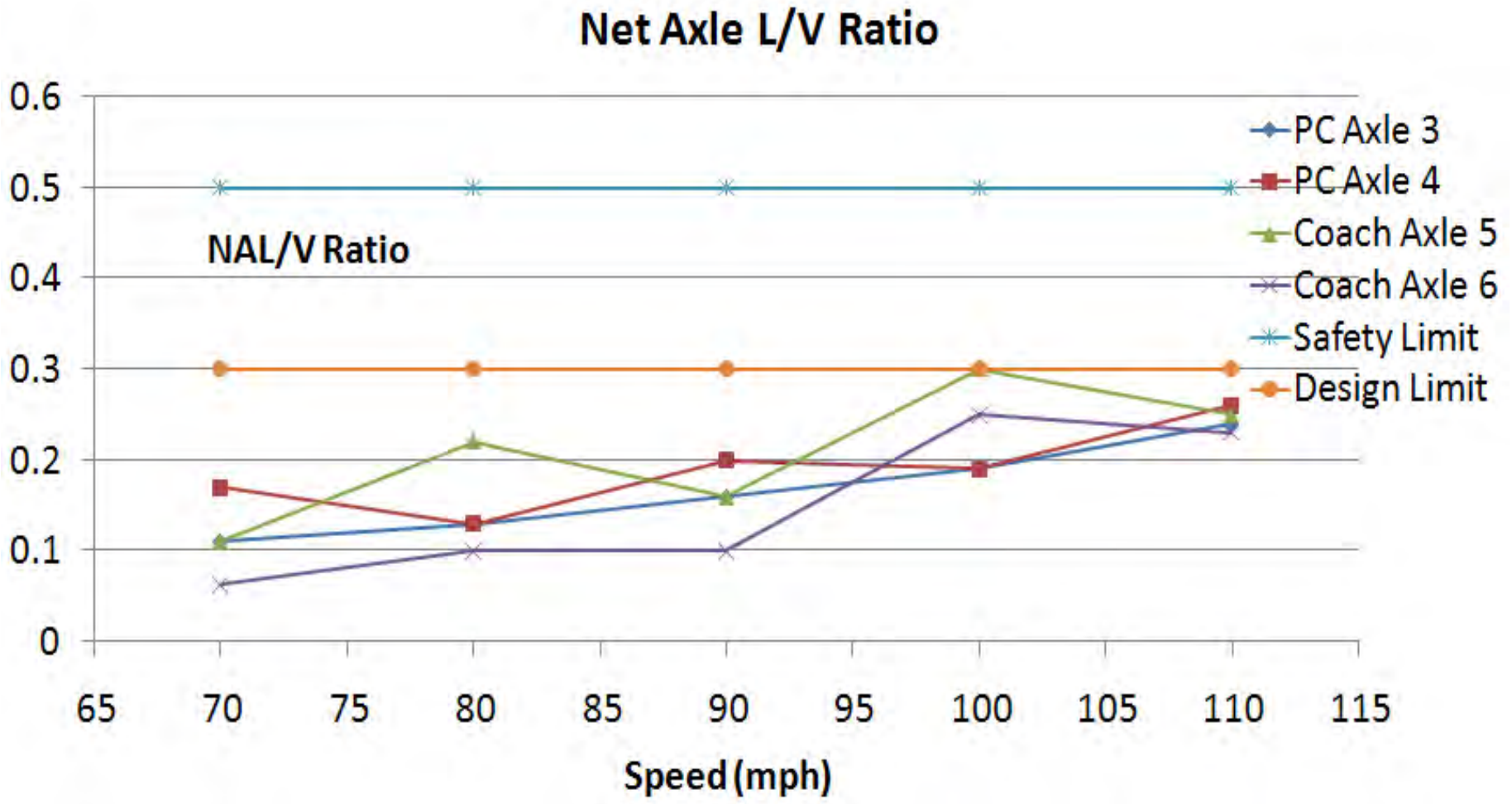

Truck Acceleration: Maximum Measured vs. Limits per FRA 213.333

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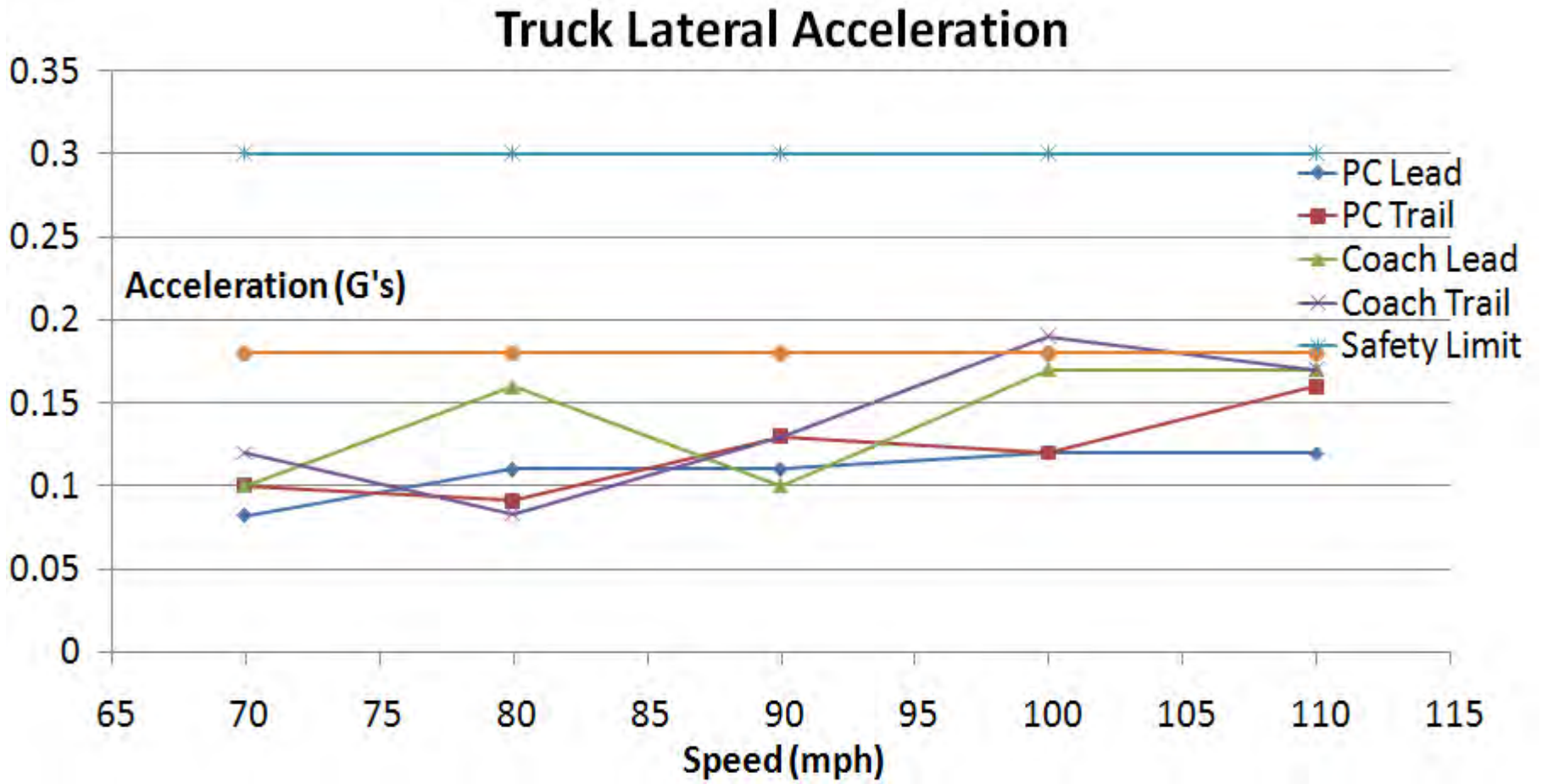

Carbody Acceleration: Maximum Measured vs. Limits per FRA 213.333

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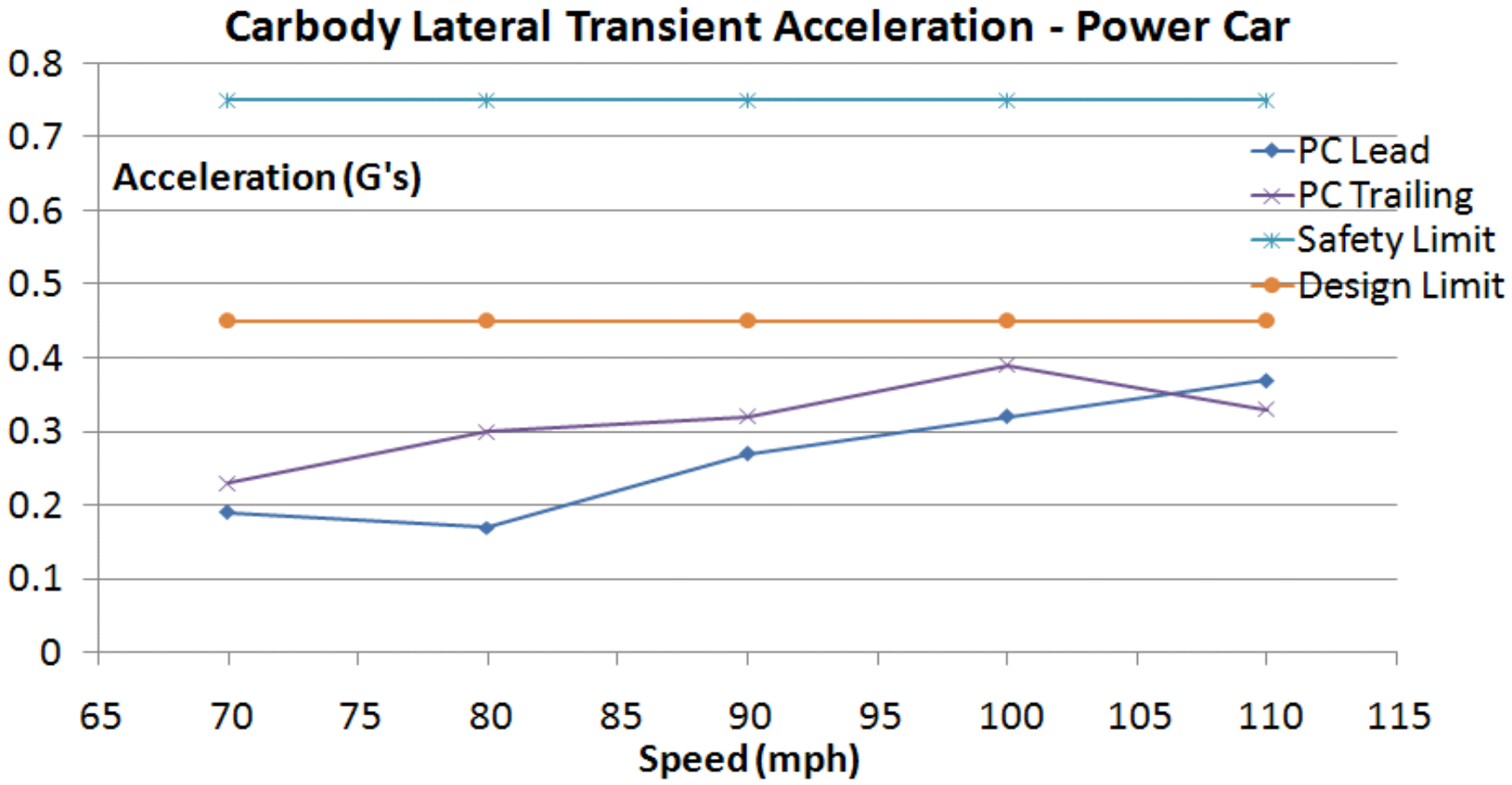

Simulating Acela in Turnouts

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IWS vs. Simulation for Open Track

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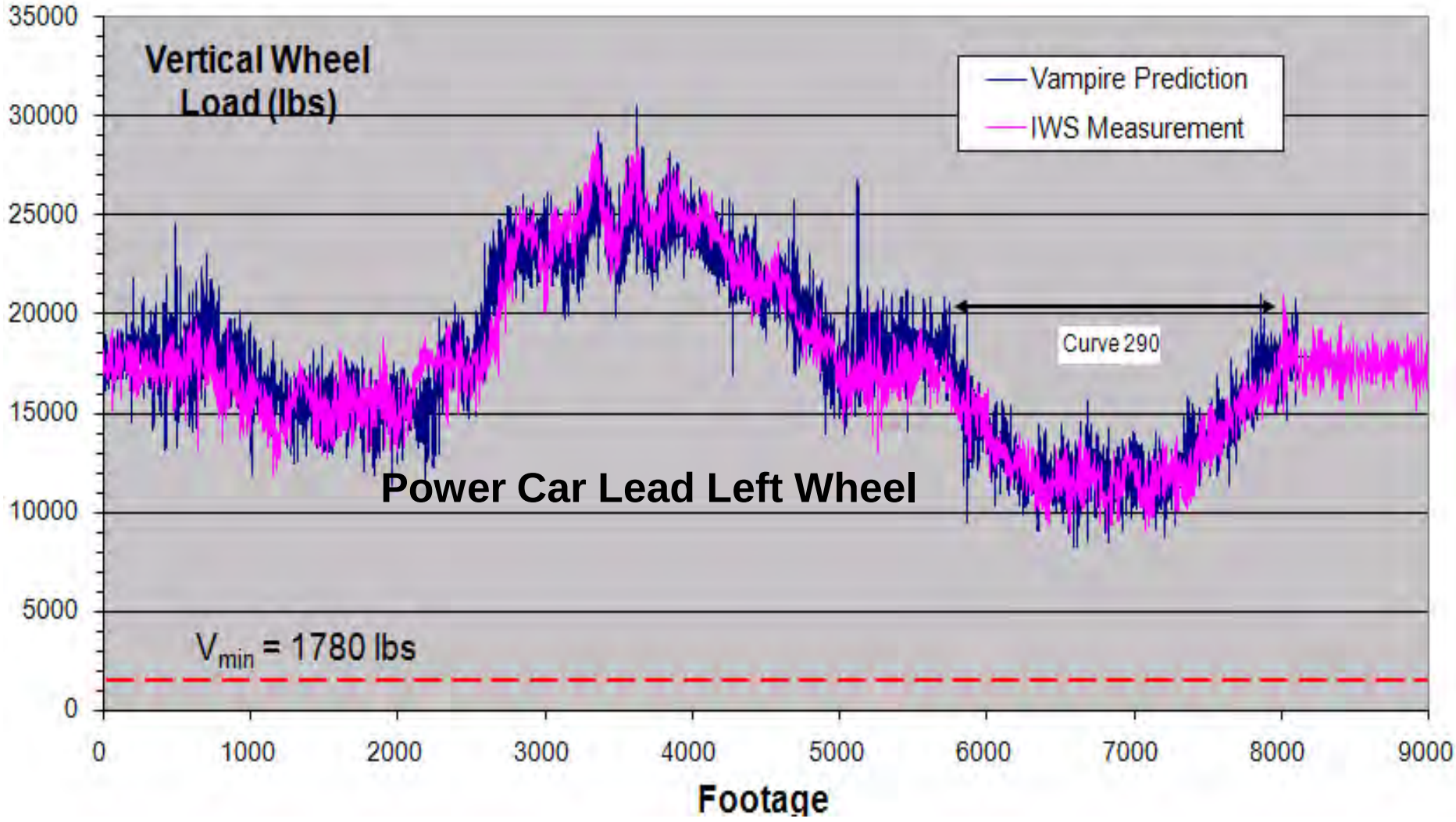

IWS vs. Simulation for Open Track

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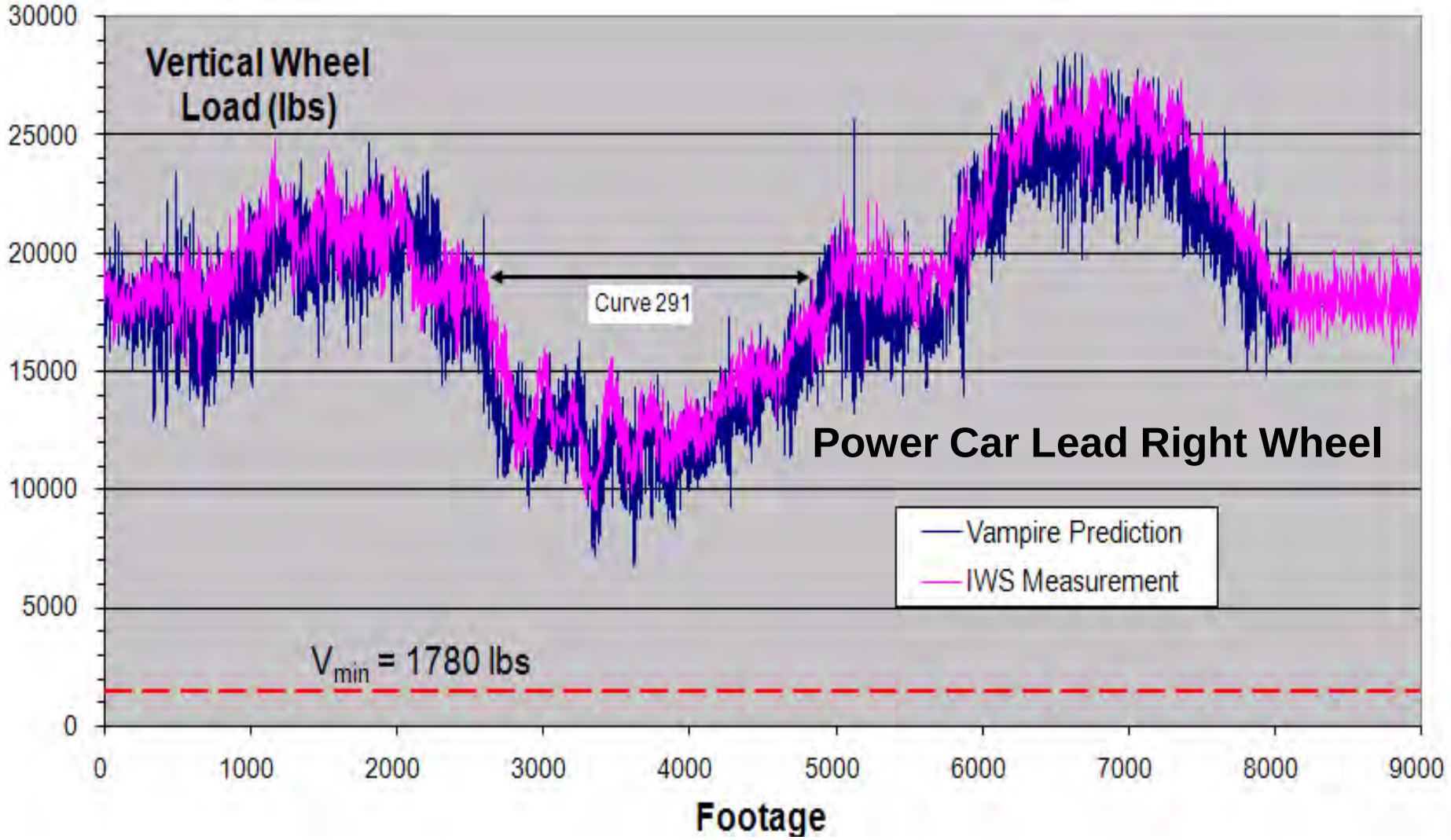

Wheel/Rail Contact Near Switch Points

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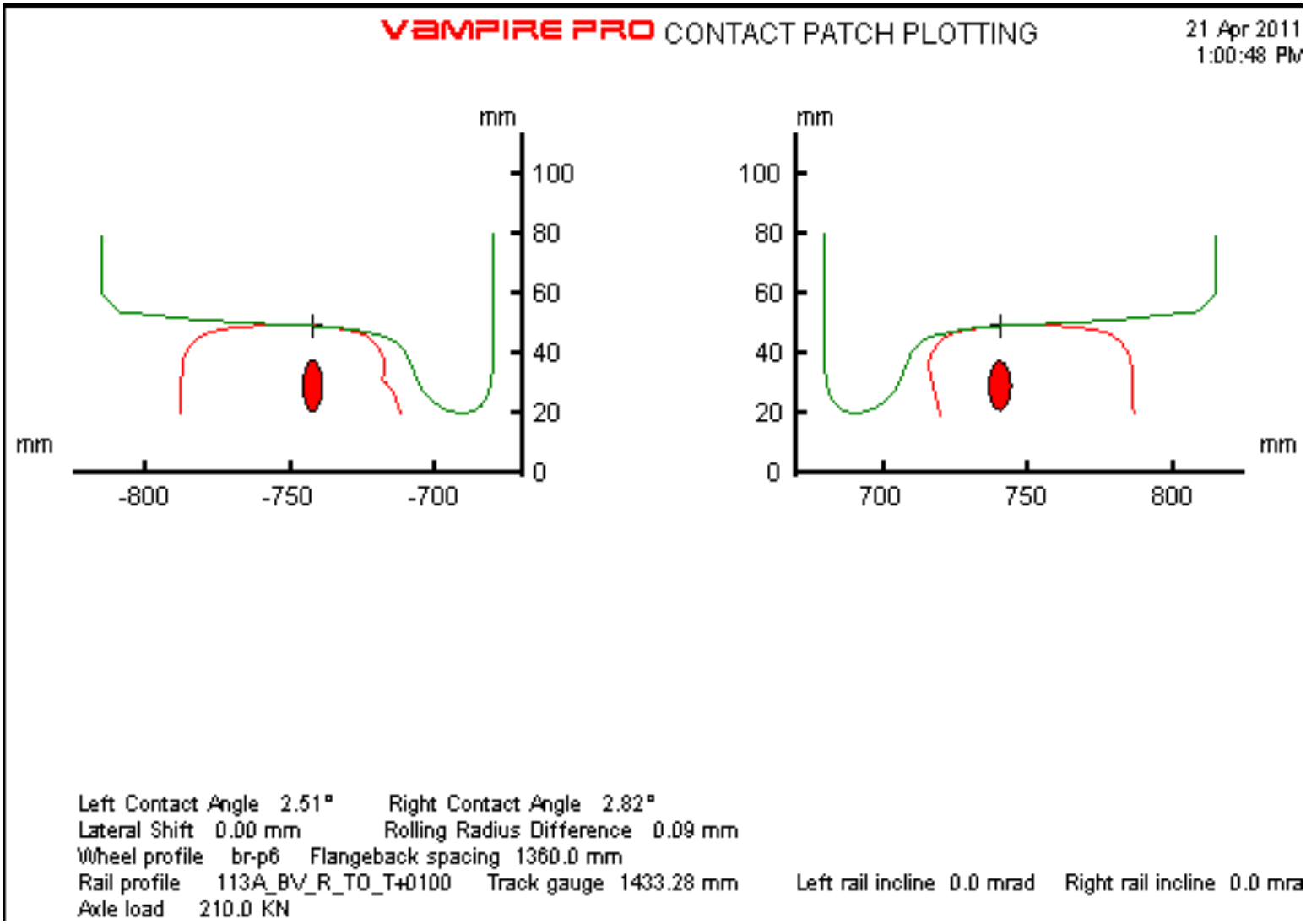

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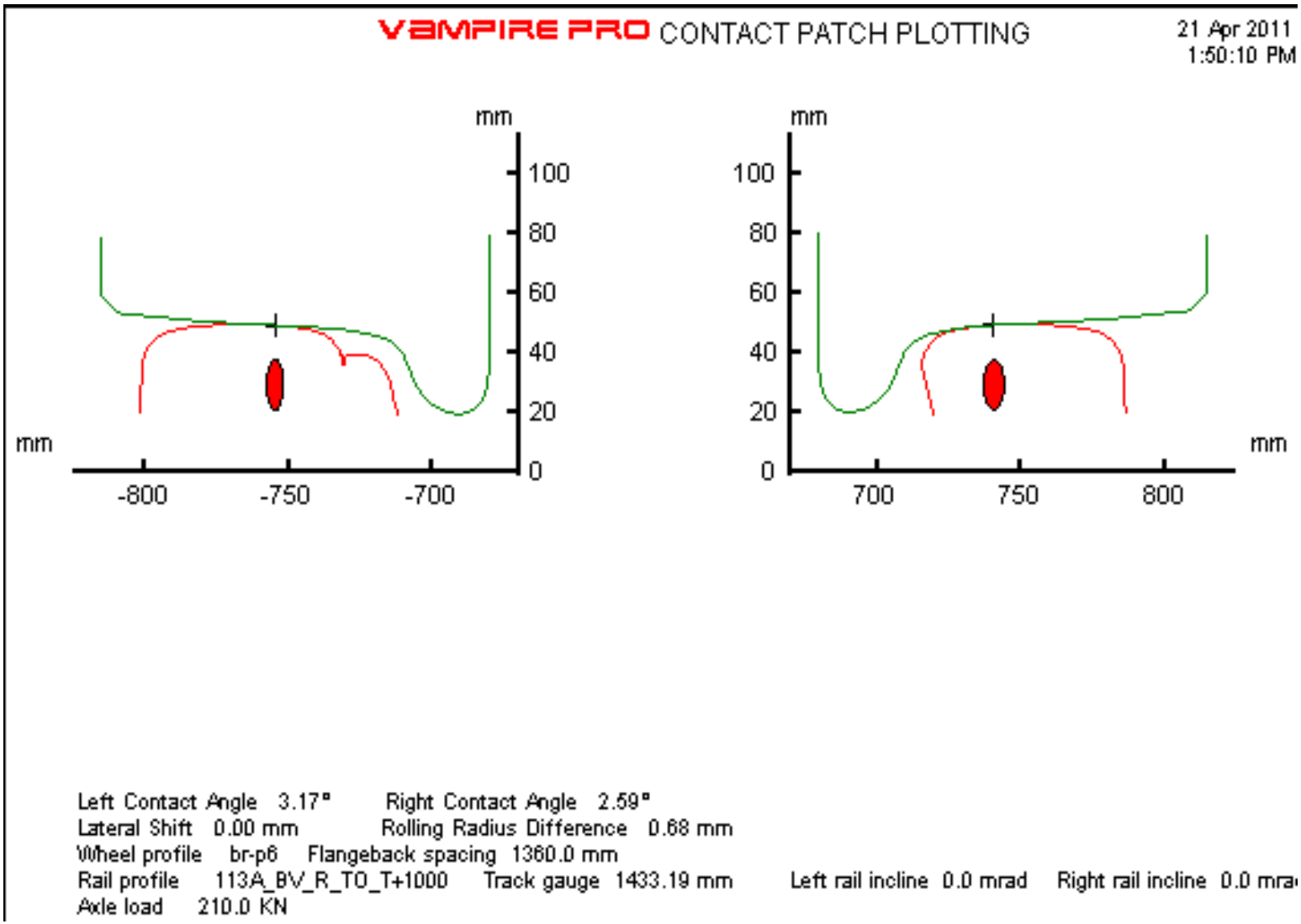

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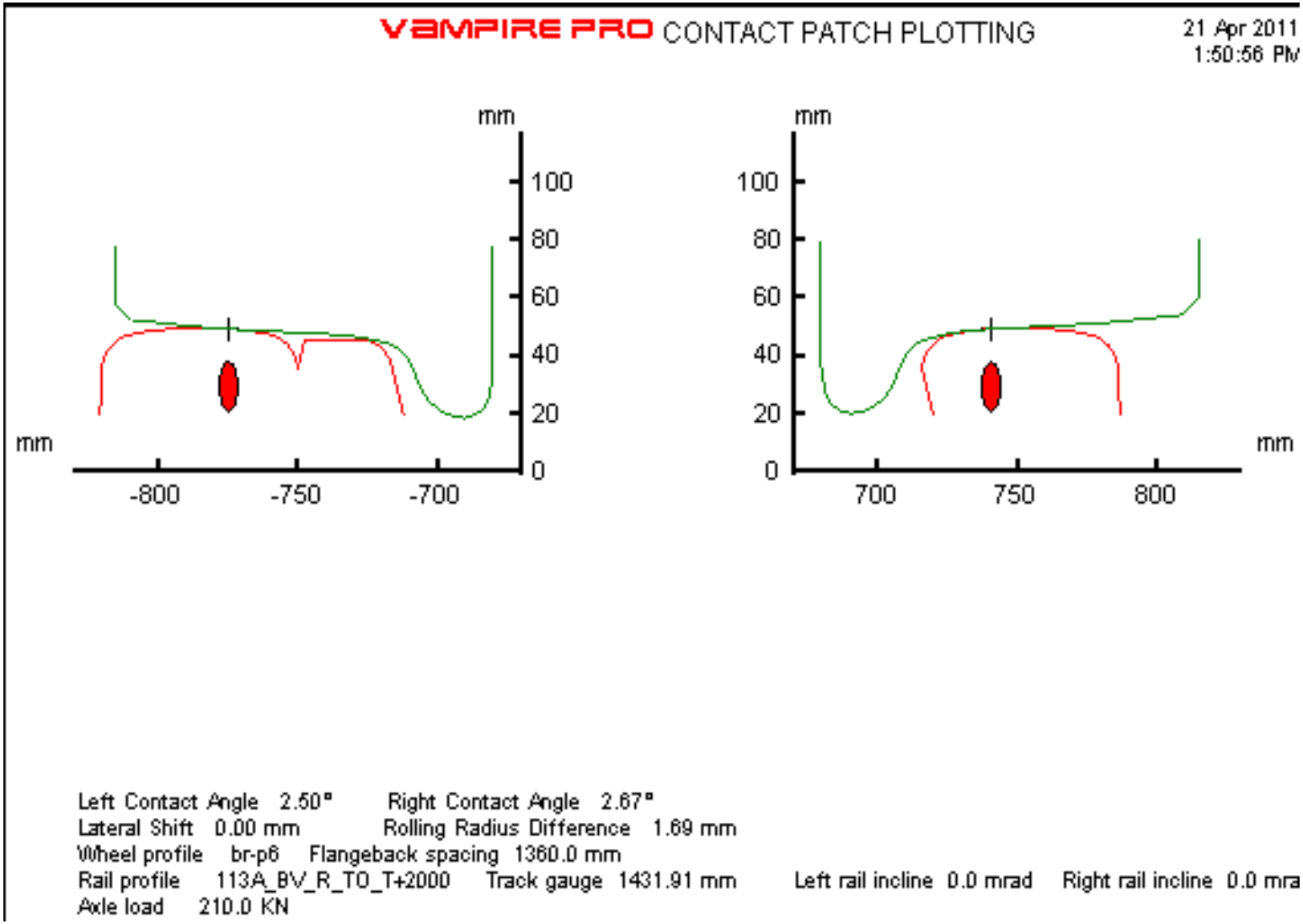

Wheel/Rail Contact Near Switch Points

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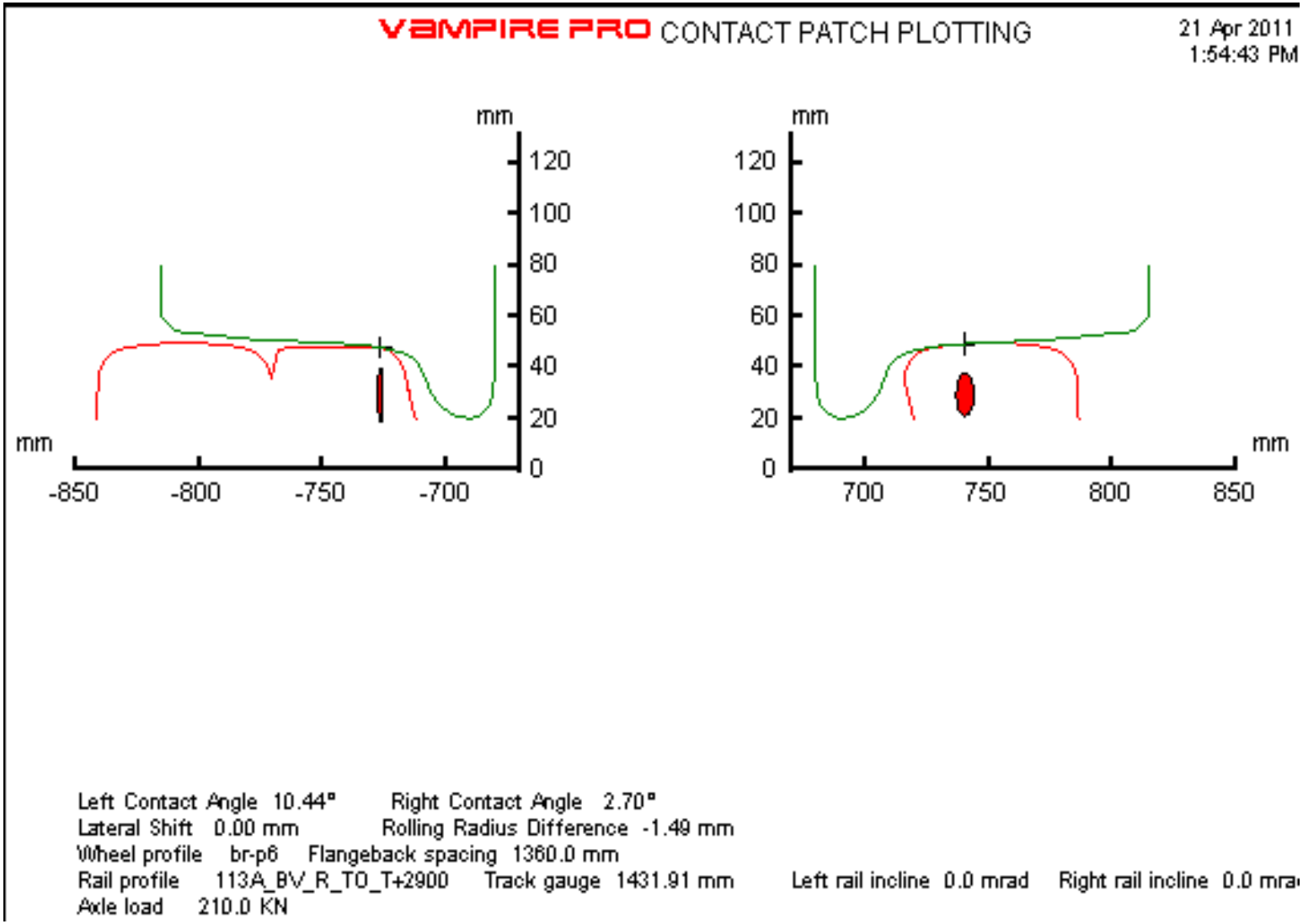

Simulating Wheelset on Diverging Route Traversing the Frog

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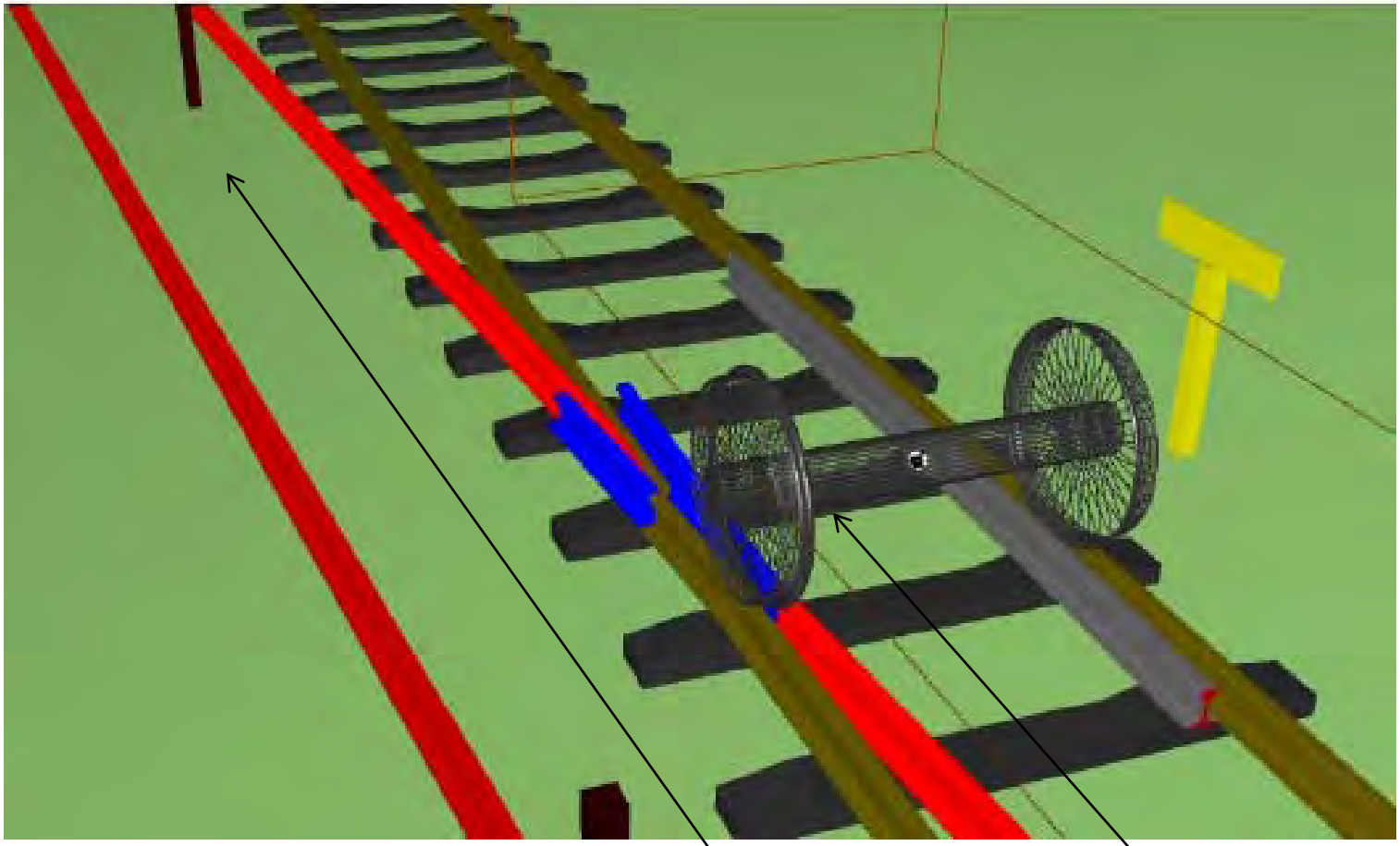

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Tentative Conclusions

- Testing shows it appears feasible to increase speed thru the diverging route of a 32.75 T.O. above the nominal 80 mph
- Using design limit of 60% of force & acceleration safety limit appears reasonable to govern allowable speed

Future Work

- Simulations will use measured rail friction and rail profiles thru T.O. to compare predictions w/ measurements
- Next generation T.O. design phase will use simulations to reduce forces and accelerations further
- Will look at changing geometry and improving rolling radius to lower forces thru switch points

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Acknowledgements

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- TTCI provided software support for IWS measurements