



U.S. Department
of Transportation
**Federal Railroad
Administration**



OFFICE OF RESEARCH DEVELOPMENT & TECHNOLOGY
FRA OFFICE OF RAILROAD POLICY & DEVELOPMENT

FRA Best Practices Workshop on VTI Simulation

July 1, 2015

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FRA OFFICE OF RESEARCH, DEVELOPMENT, AND TECHNOLOGY

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MECHANICAL ENGINEER
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Moving America Forward

FRA – Office of Research, Development, and Technology

6/30/2015



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FRA Best Practices Workshop on VTI Simulation Modeling challenges facing FRA

- **Example VTI Modeling Research Needs**

- ❖ Suspension Modeling – Coil Springs
- ❖ Creepage/Creep Force Modeling
- ❖ Conformal Contact
- ❖ Stability
- ❖ Improved Track Geometry Space Curve Data Measured by Geometry Vehicles to be Suitable for Dynamic Modeling – Development of Common Input Standard
- ❖ Improved Track Modeling

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- ❖ **Suspension Modeling – Coil Springs**

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- ❖ Conformal Contact

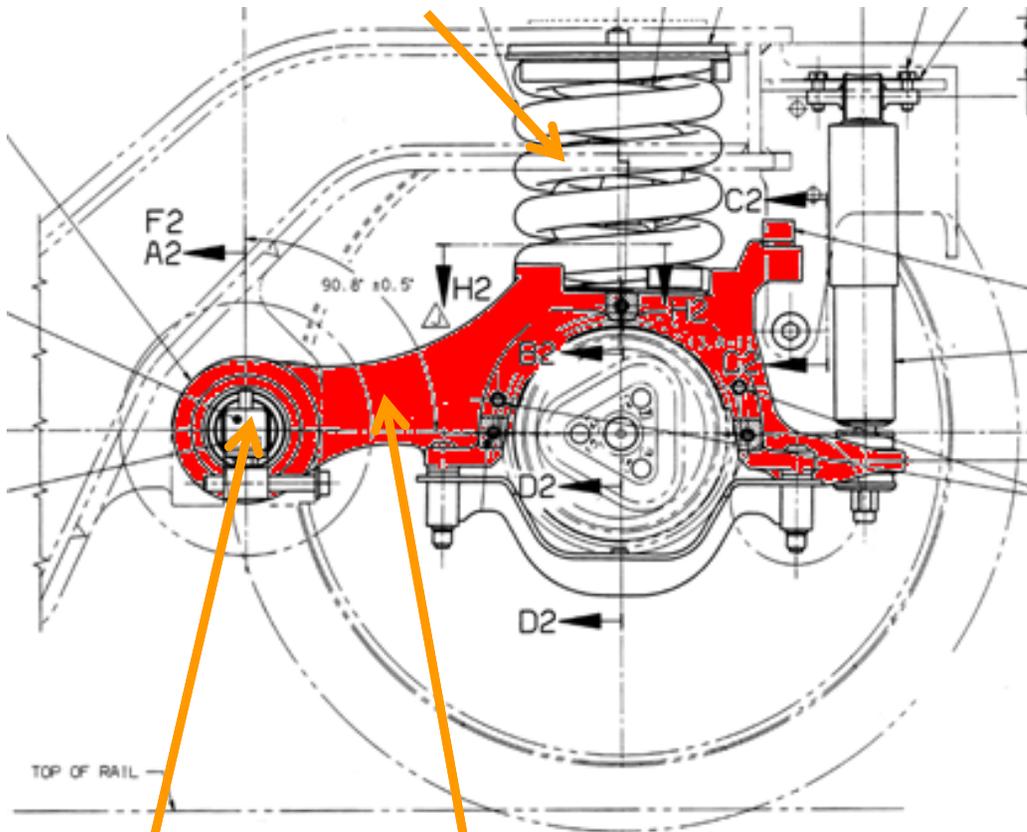
- ❖ Stability

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Suspension modeling – Coil Springs

Primary Suspension Coil



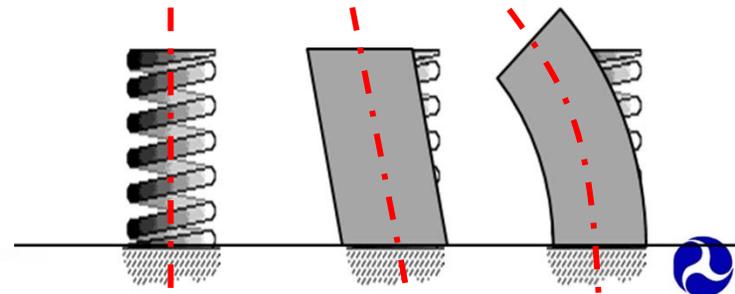
Swing Arm

Bushing

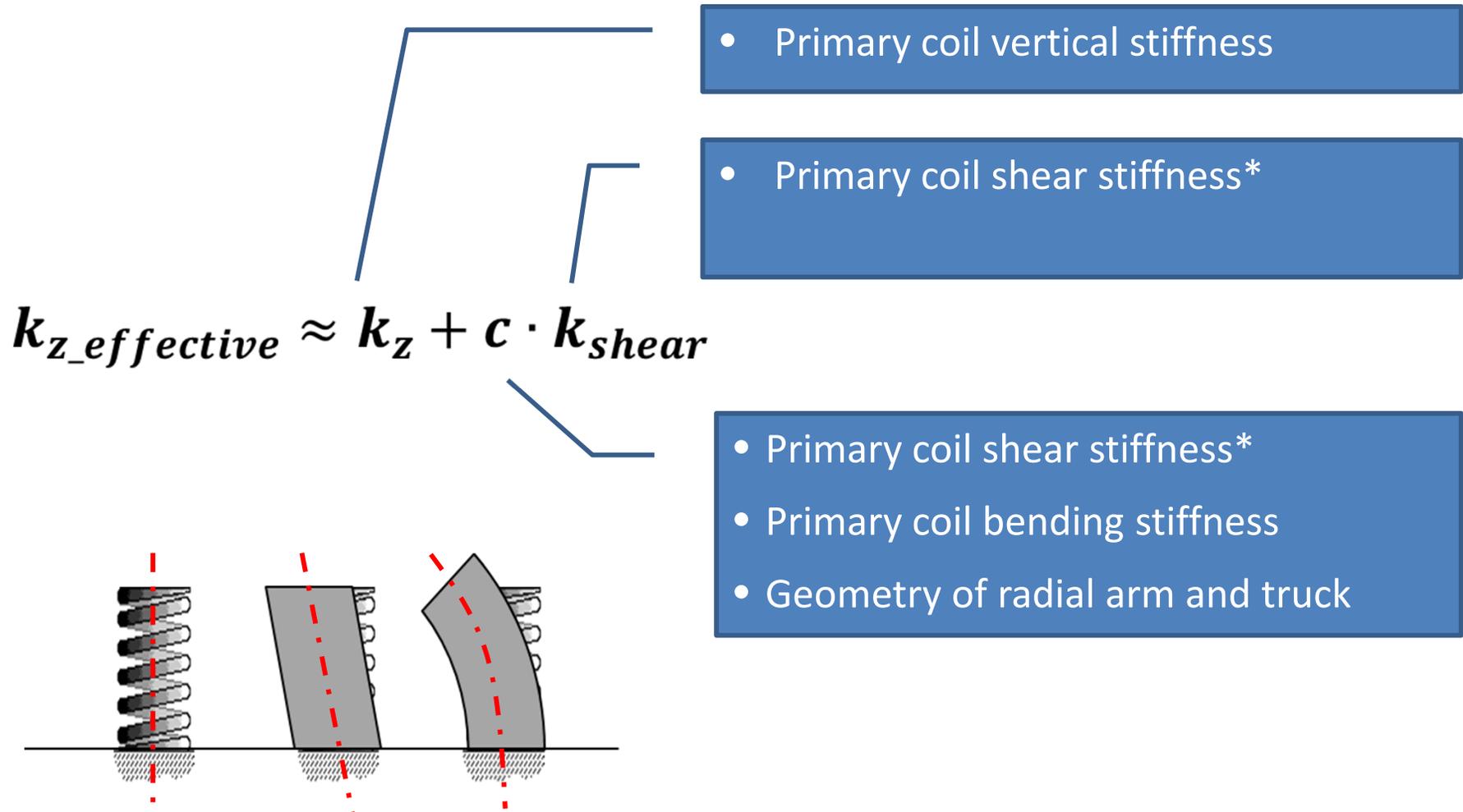
Swing Arm

Swing Arm Suspension Effects:

1. Coupling between axlebox longitudinal and vertical motion
2. Effective vertical stiffness
 - “Suspension” vertical stiffness is greater than primary coil vertical stiffness
 - Increase is due to primary coil longitudinal and pitch deflections (i.e. spring shear and spring bending stiffness)

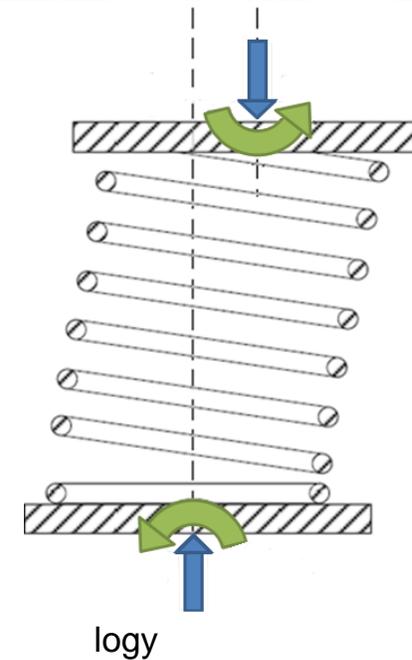
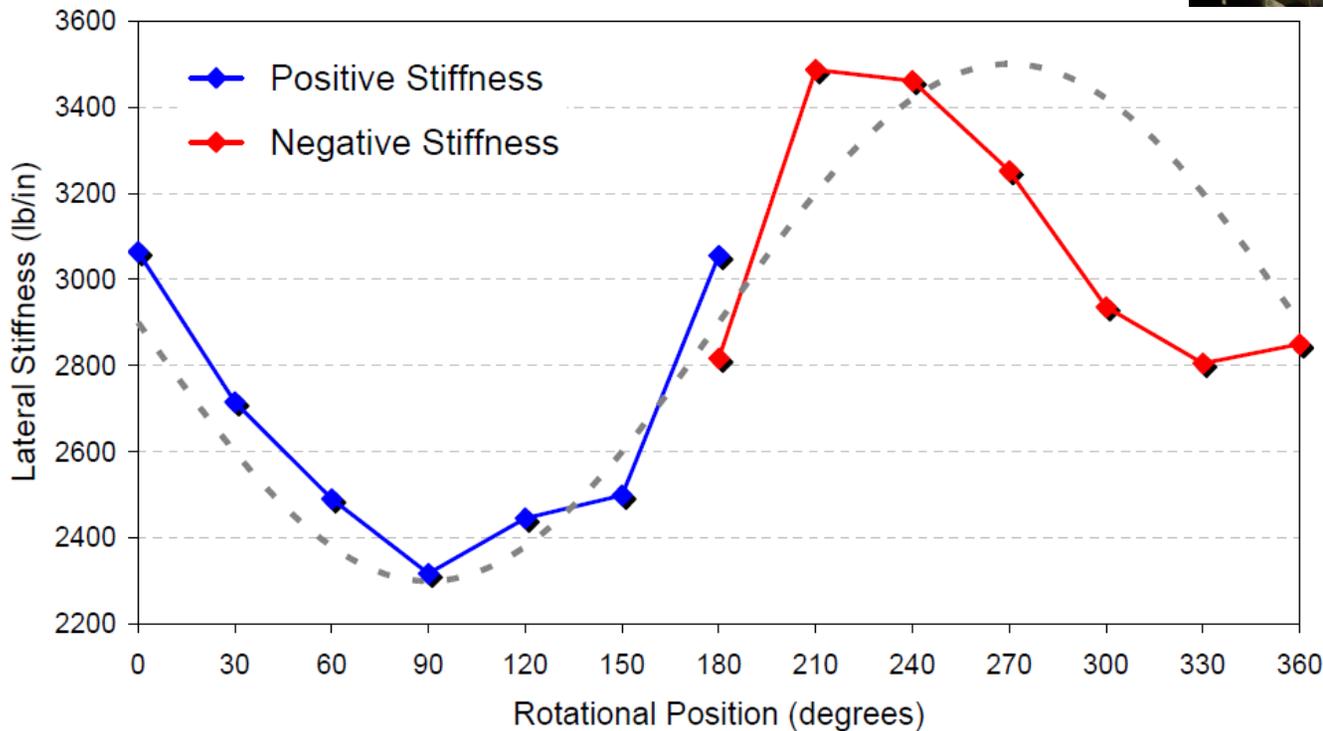
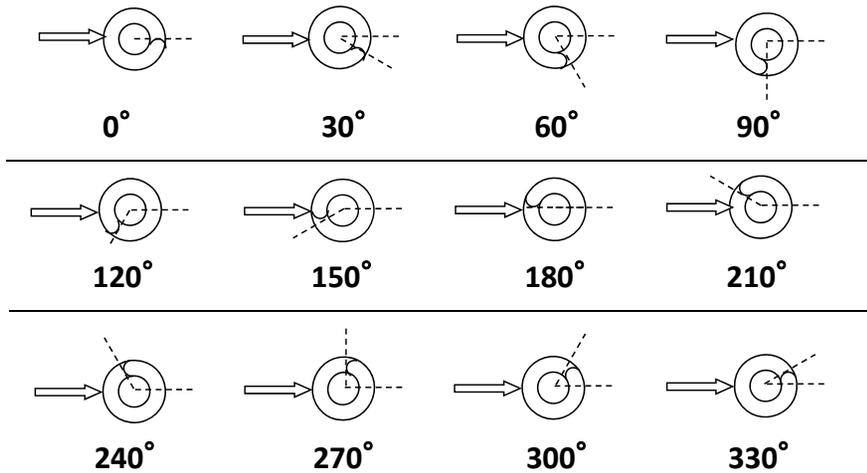


Suspension modeling – Coil Springs



Suspension modeling – Coil Springs

Shear stiffness of spring dependent on orientation

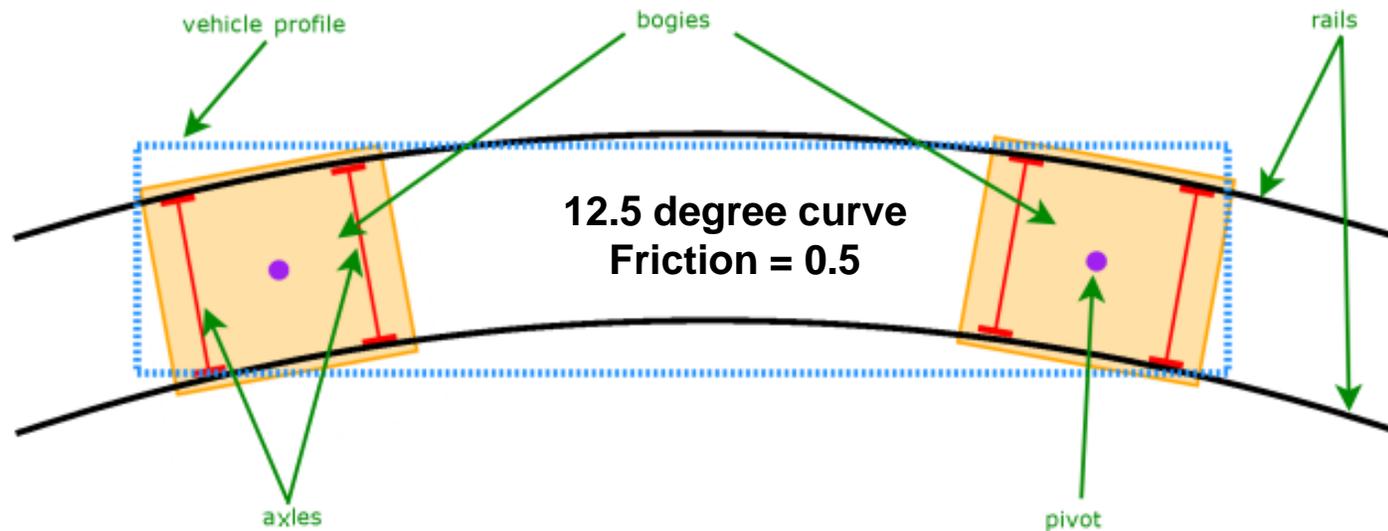


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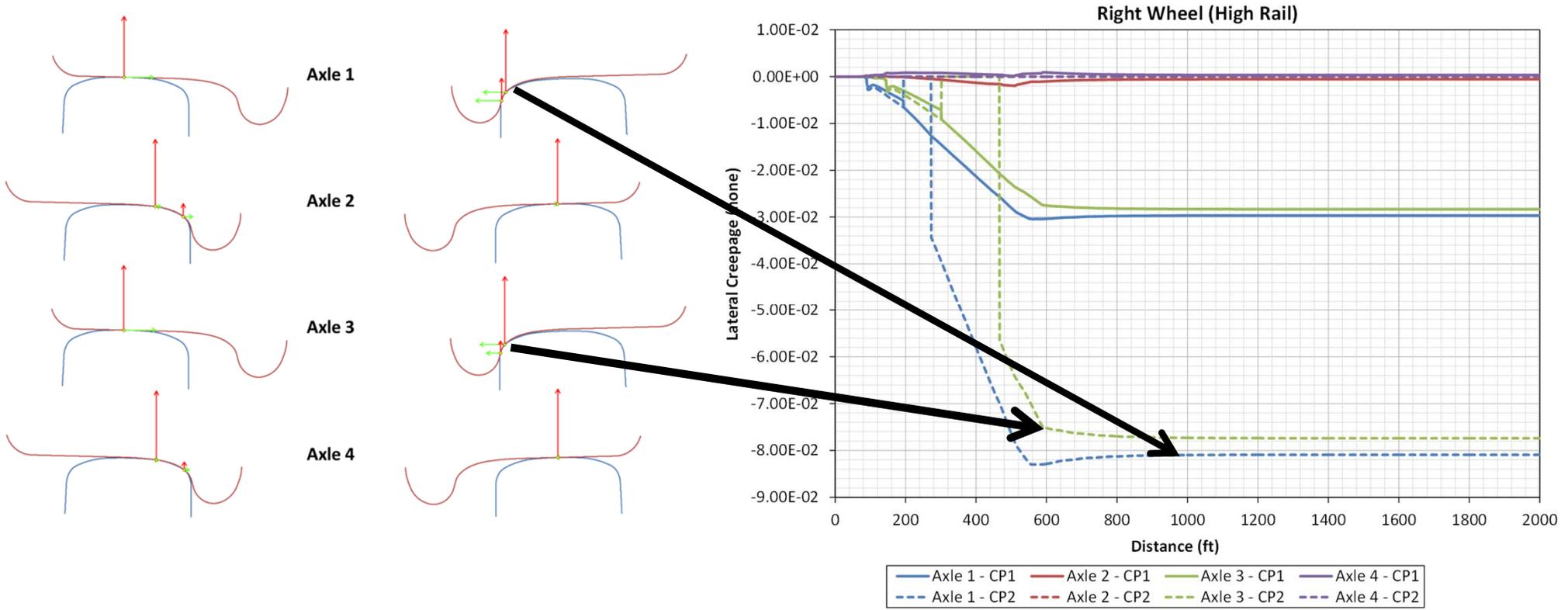
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Creepage/Creep Force Modeling – Evaluation of curving performance for prevention of low speed derailments

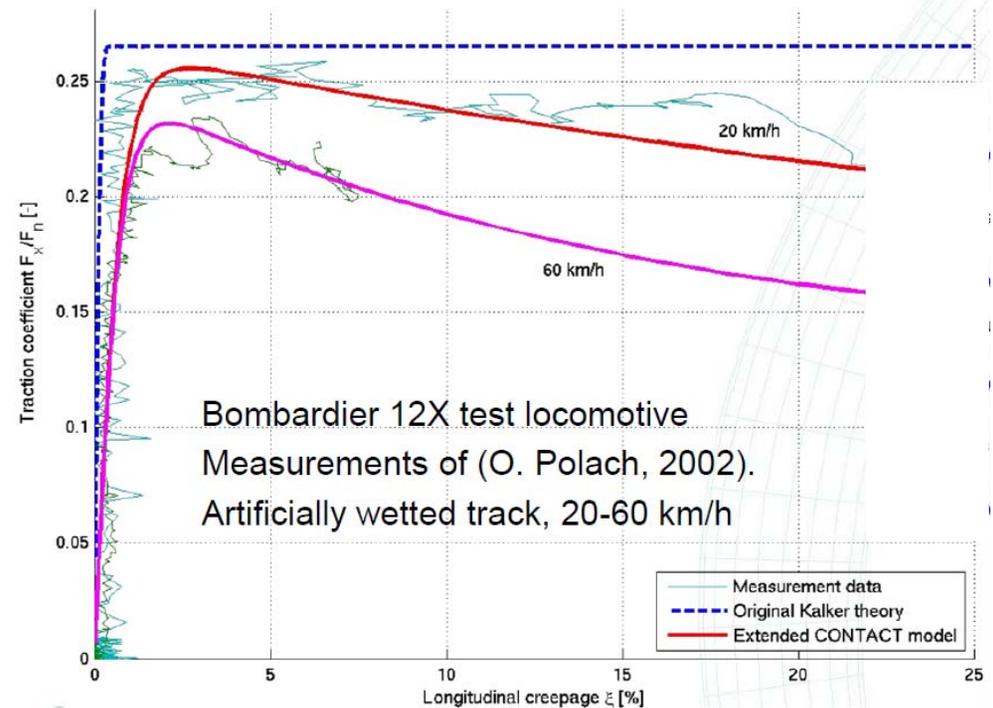
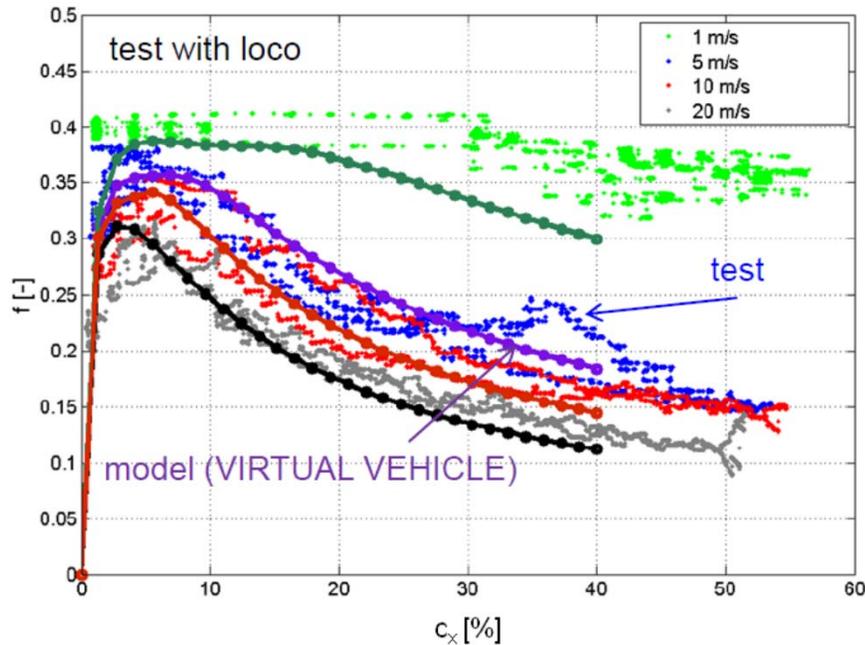


Creepage/Creep Force Modeling – Evaluation of curving performance for prevention of low speed derailments



Creepage/Creep Force Modeling – Evaluation of curving performance for prevention of low speed derailments

In modeling of derailments, effects related to “falling friction” should be captured.



Ref: ICRI Friction Modeling presentation by Dr. Klaus Six of Virtual Vehicle Research Center, October 13, 2013

Ref: ICRI Friction Modeling presentation by Dr. Edwin Vollebregt of VORtech deals with the TU Delft, November 13, 2013

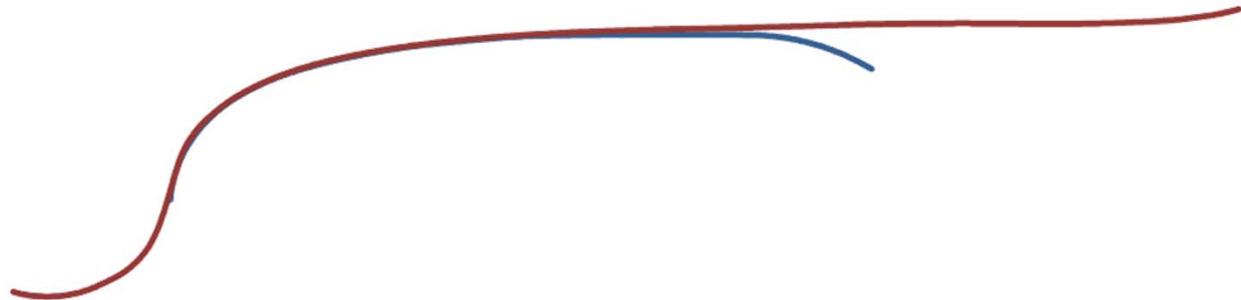
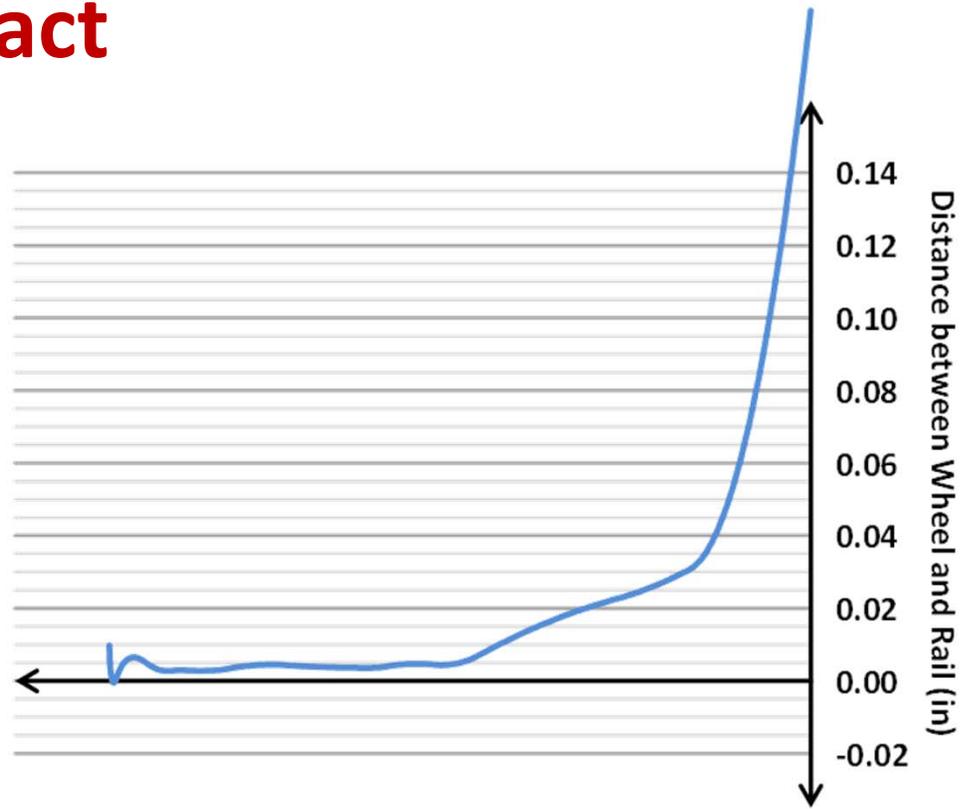
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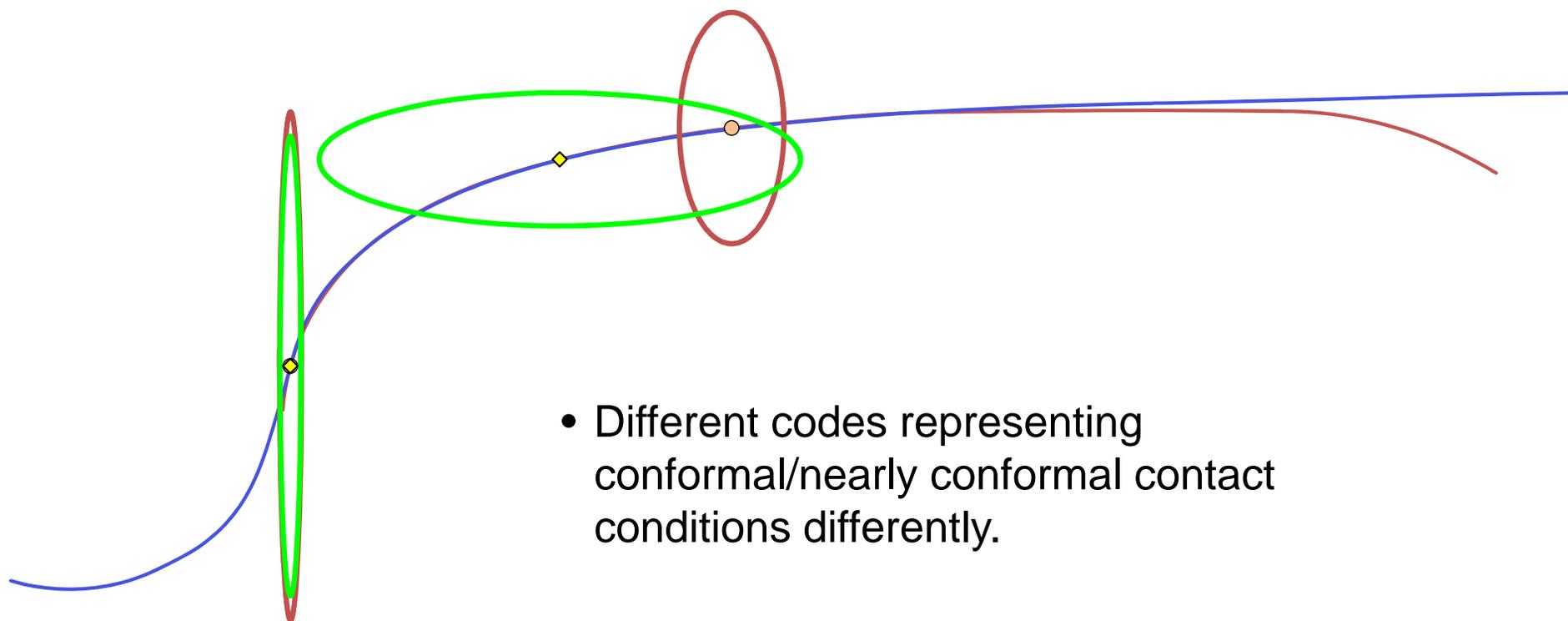
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Conformal Contact

- Conformal/nearly conformal contact conditions found on NEC in North America.

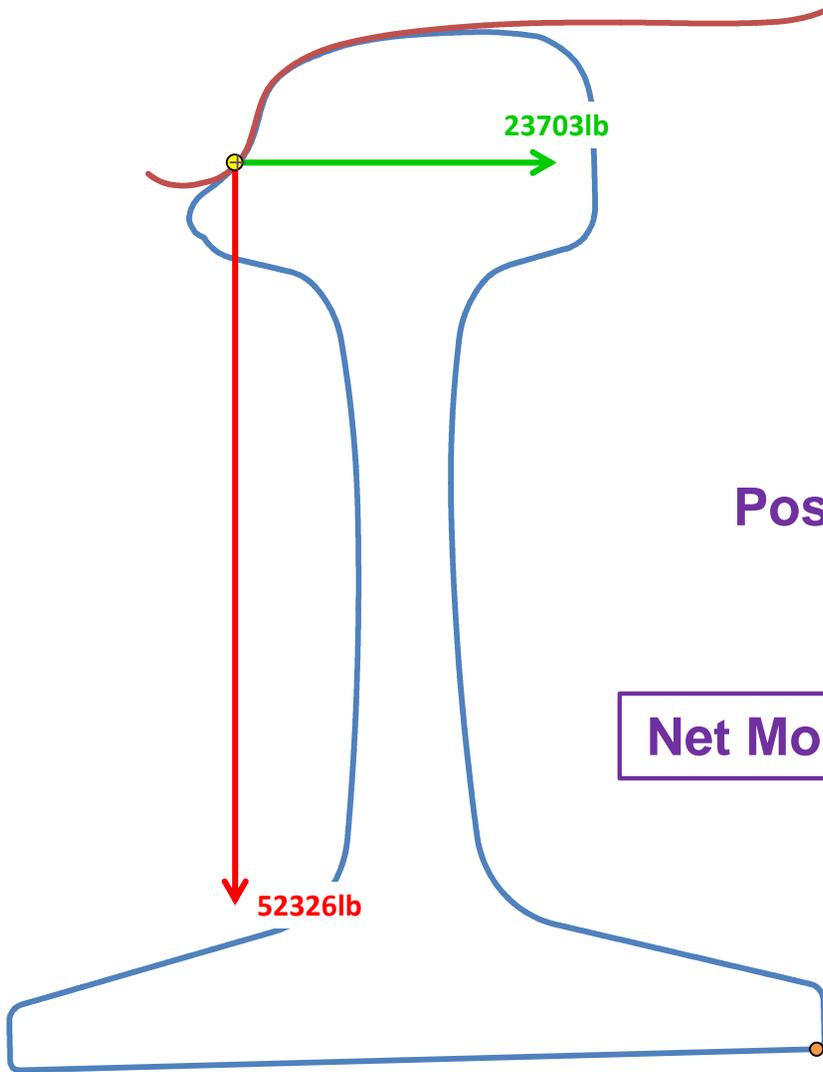


Conformal Contact



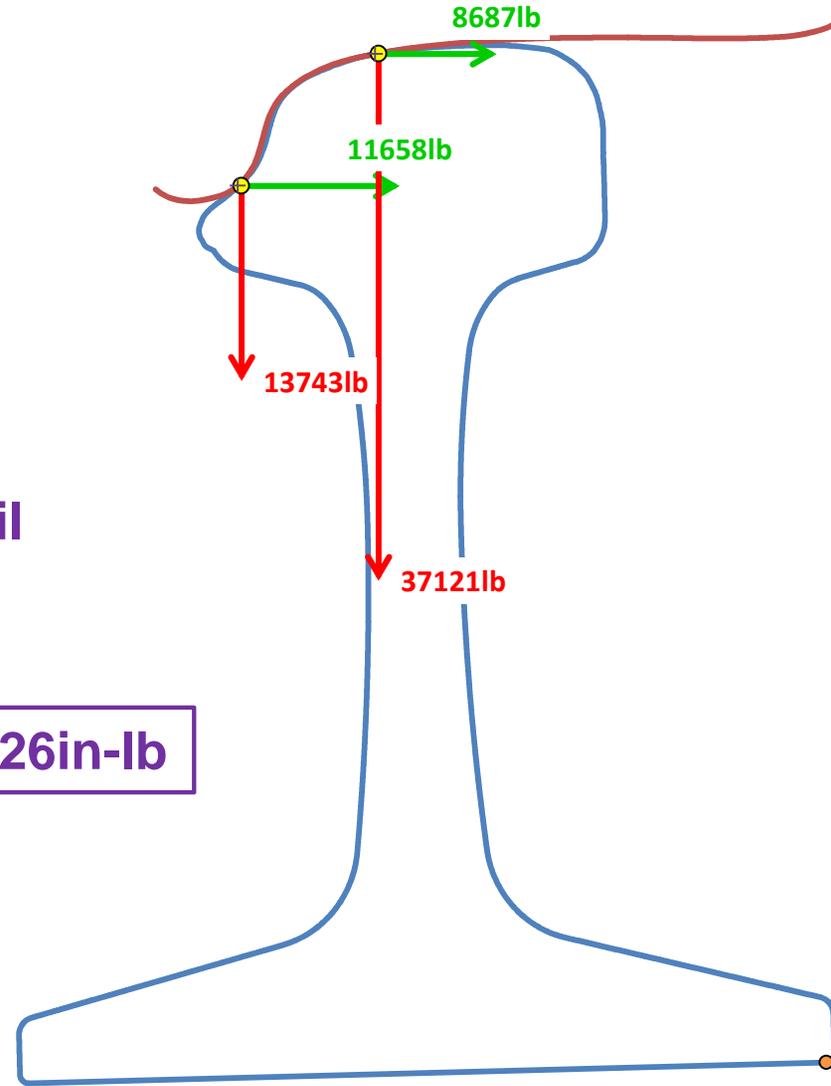
- Different codes representing conformal/nearly conformal contact conditions differently.

Axle 1



Axle 1 Net Moment: -76,095in-lb

Axle 2



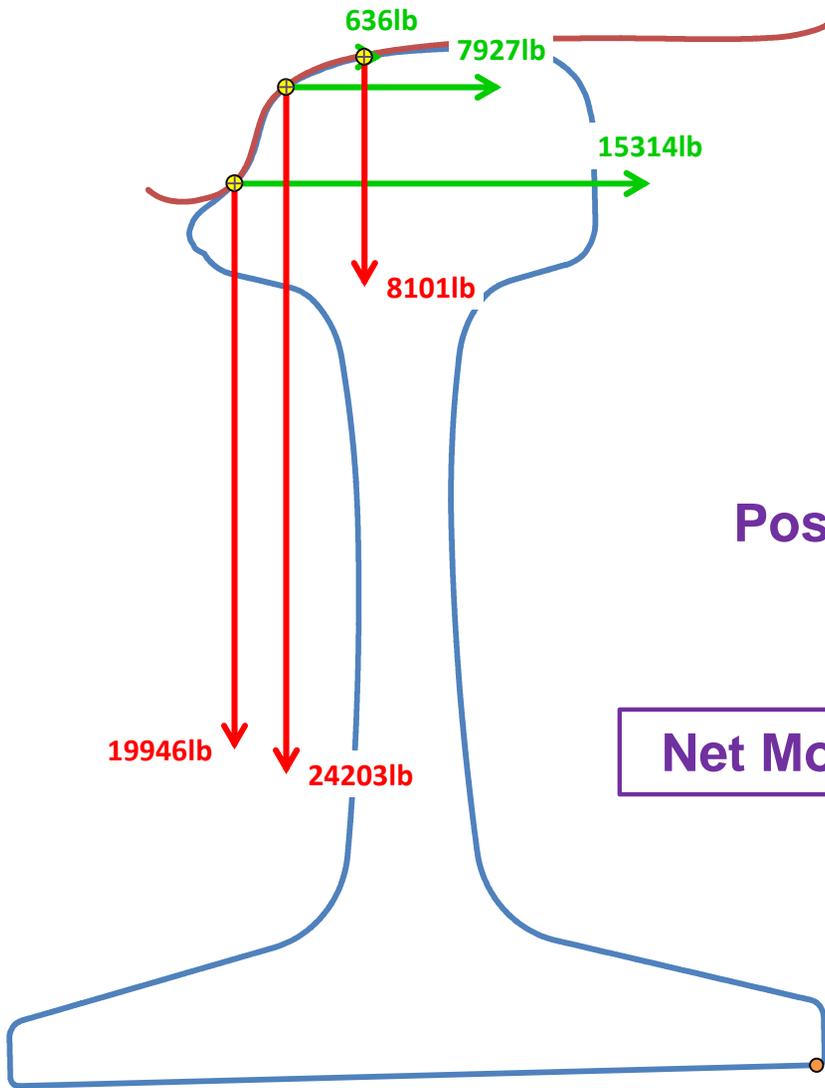
Axle 2 Net Moment: -47,931in-lb

Positive rolls rail



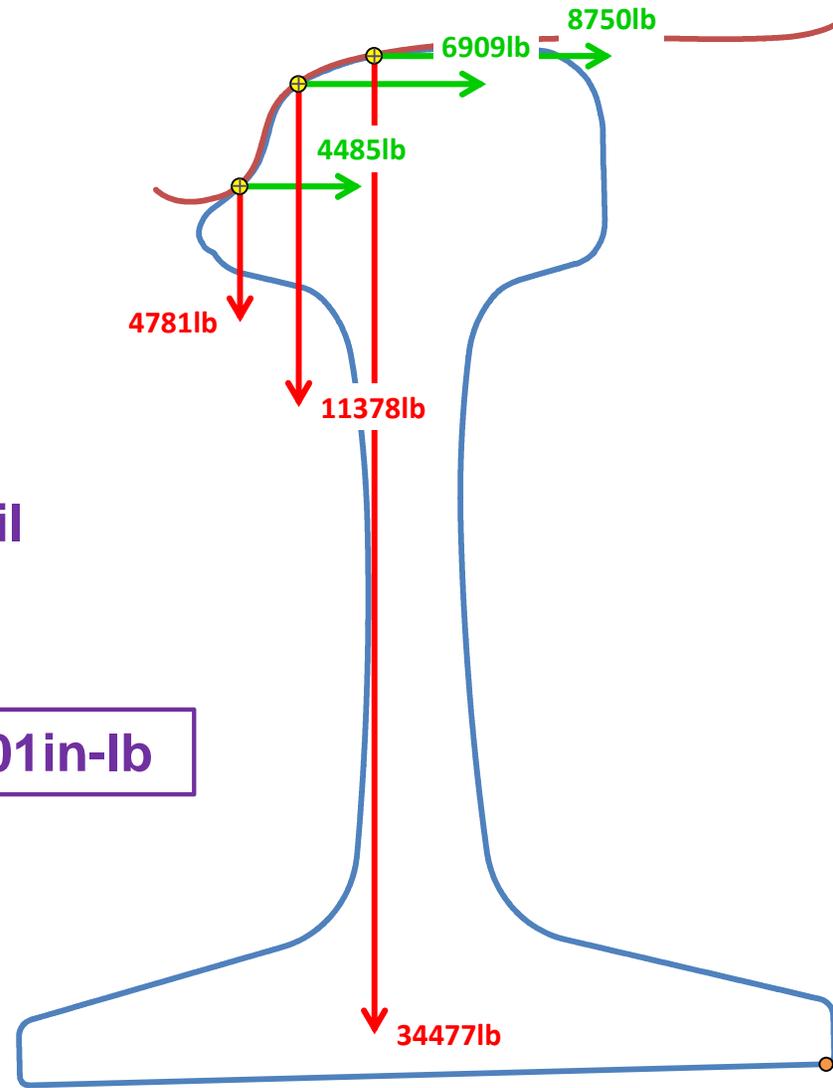
Net Moment: -124,026in-lb

Axle 1



Axle 1 Net Moment: -52,865in-lb

Axle 2



Axle 2 Net Moment: -42,036in-lb

Positive rolls rail



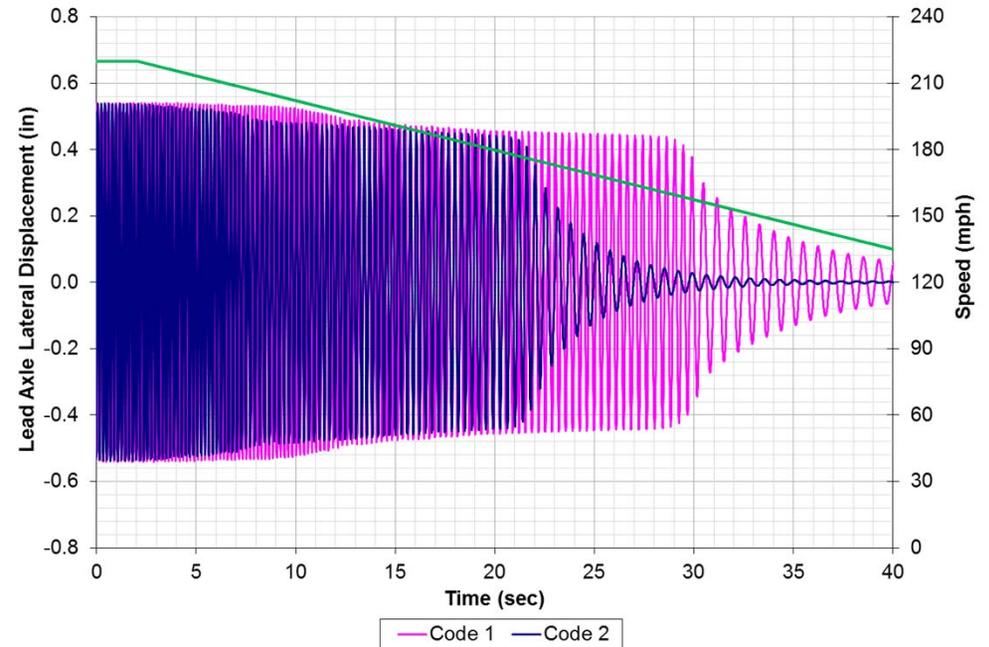
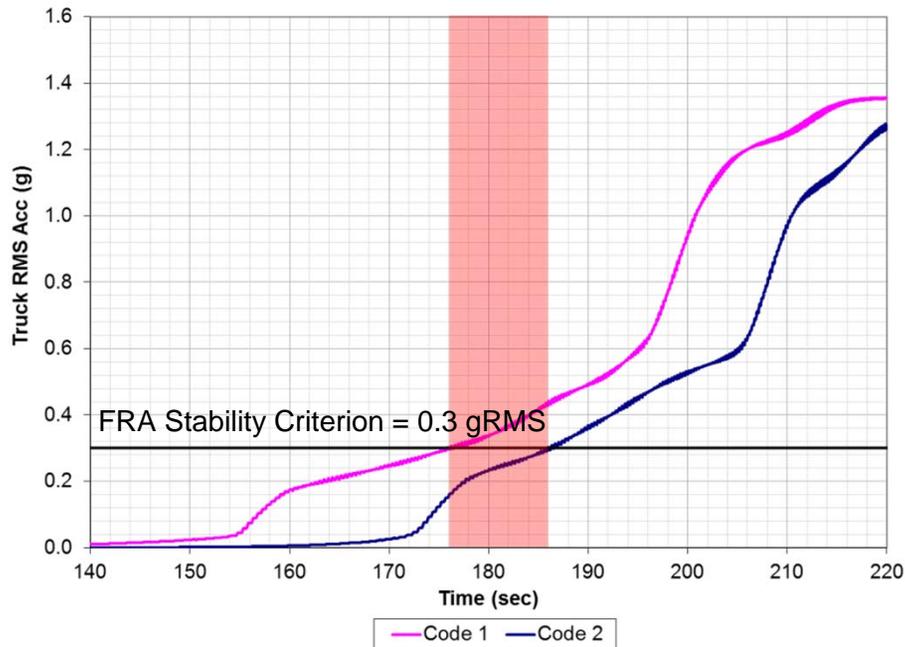
Net Moment: -96,901in-lb

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Stability



Prediction of Non-linear Hunting Speed

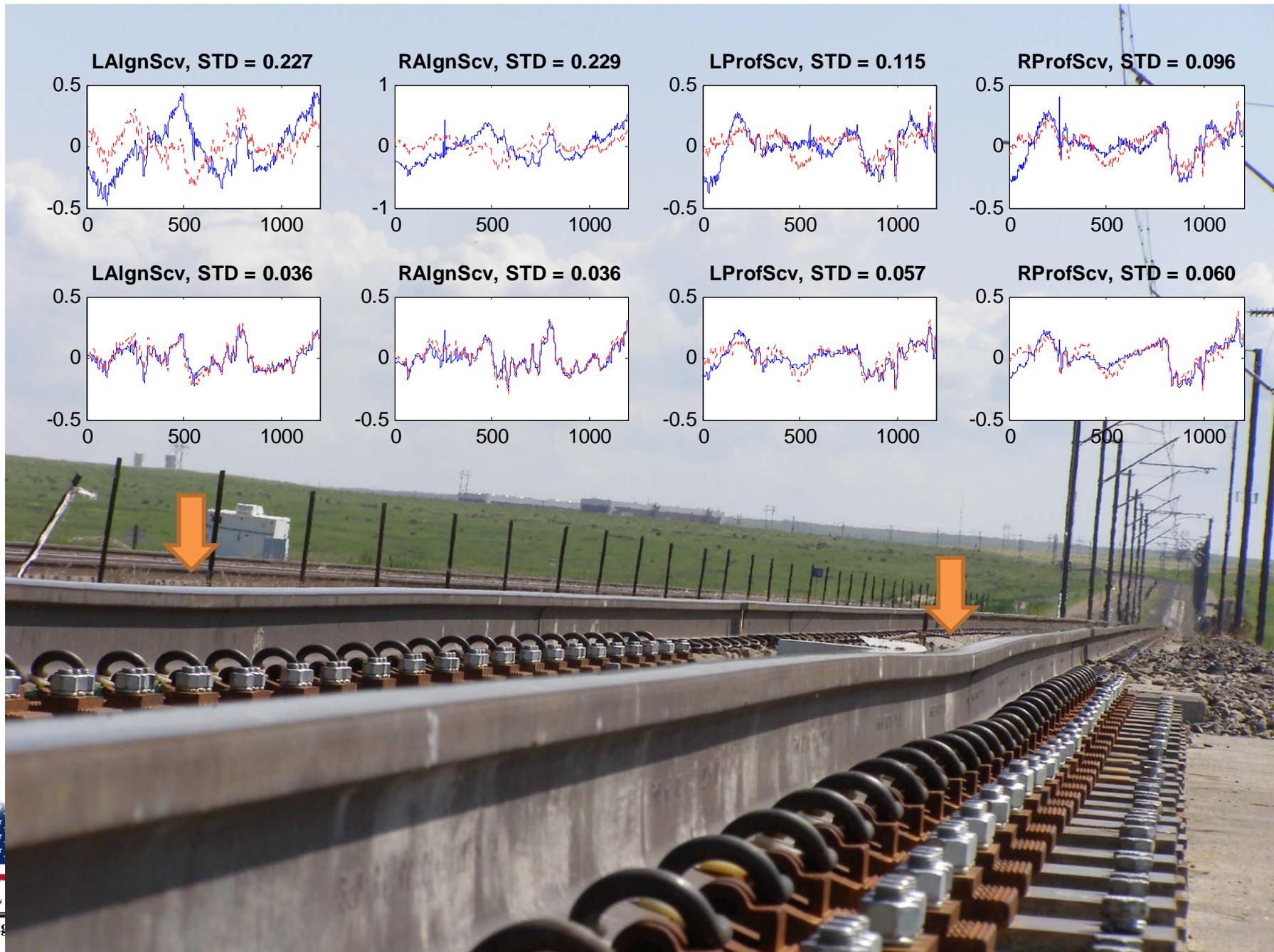
- Code 1 = 176 mph
- Code 2 = 186 mph

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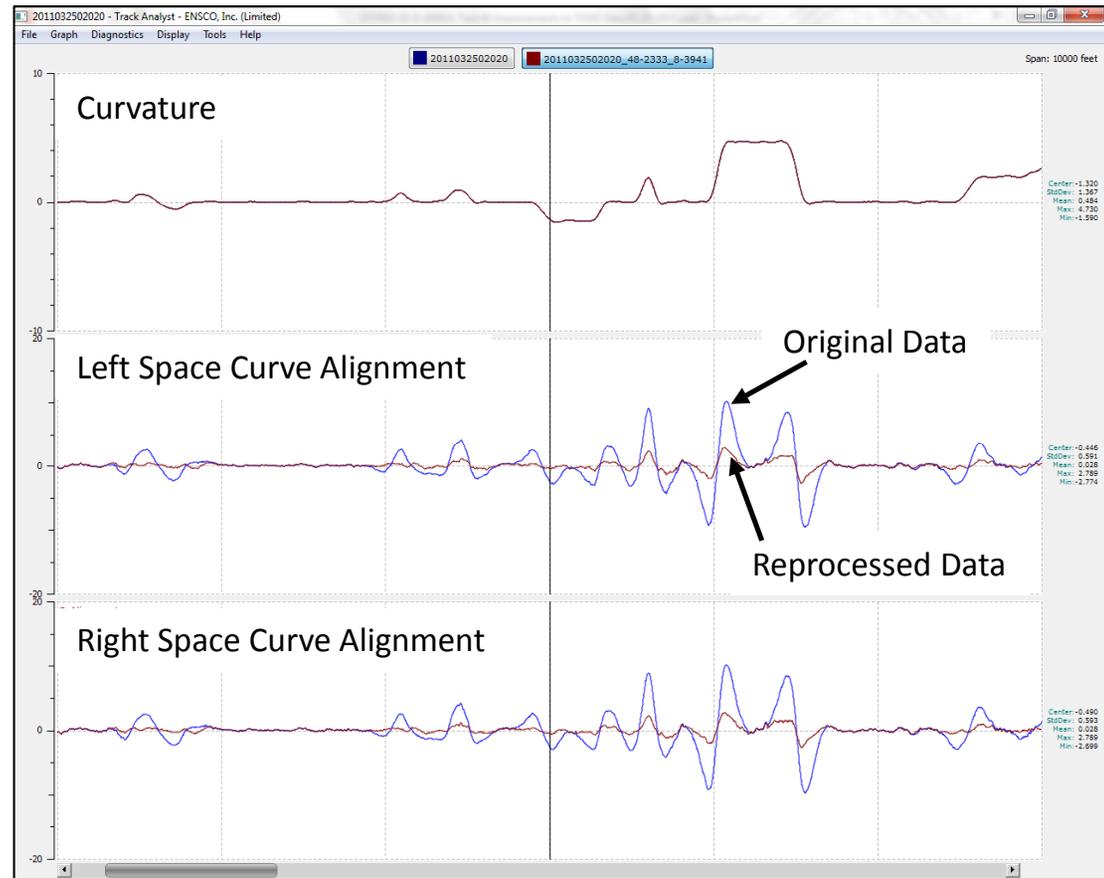
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Improved Track Geometry Space Curve Data



Improved Track Geometry Space Curve Data

- Reprocessing the space curve alignments to remove the mismatch between curvature and alignment channels at curve section.
- Applying spikes detection algorithm.
- Exporting the reprocessed track geometry data in multibody codes format.

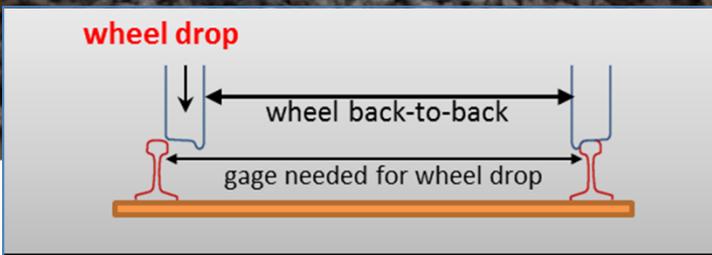
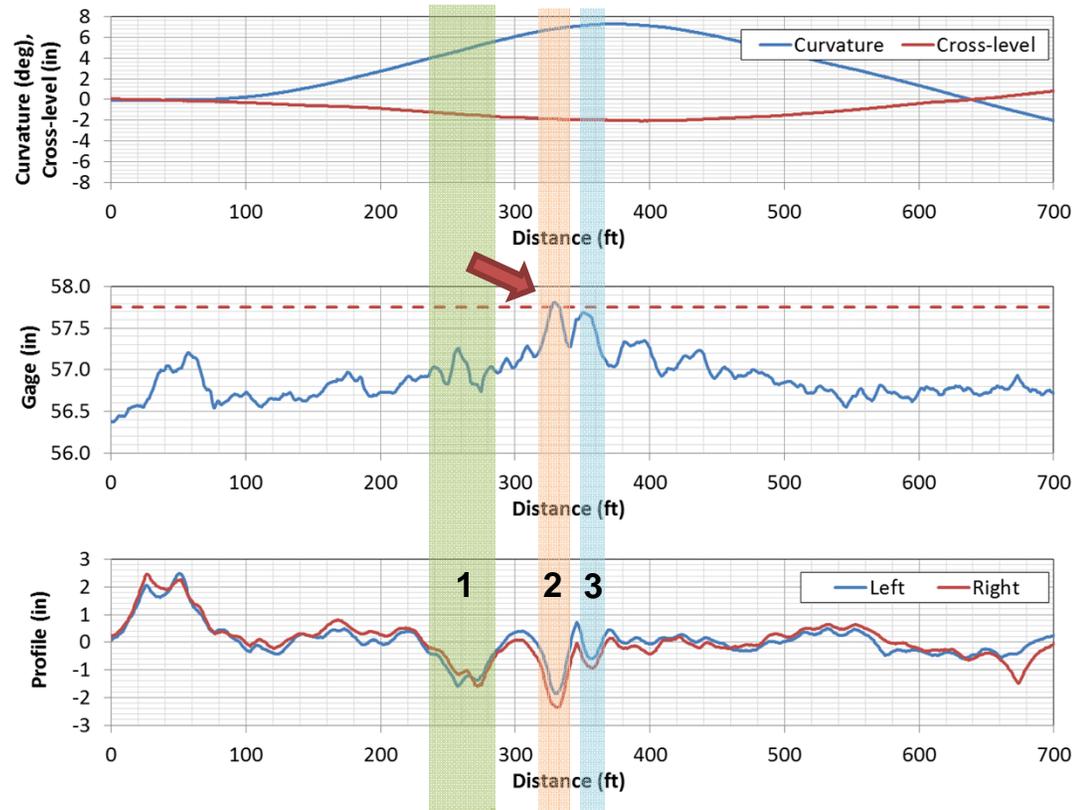


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Improved Track Modeling



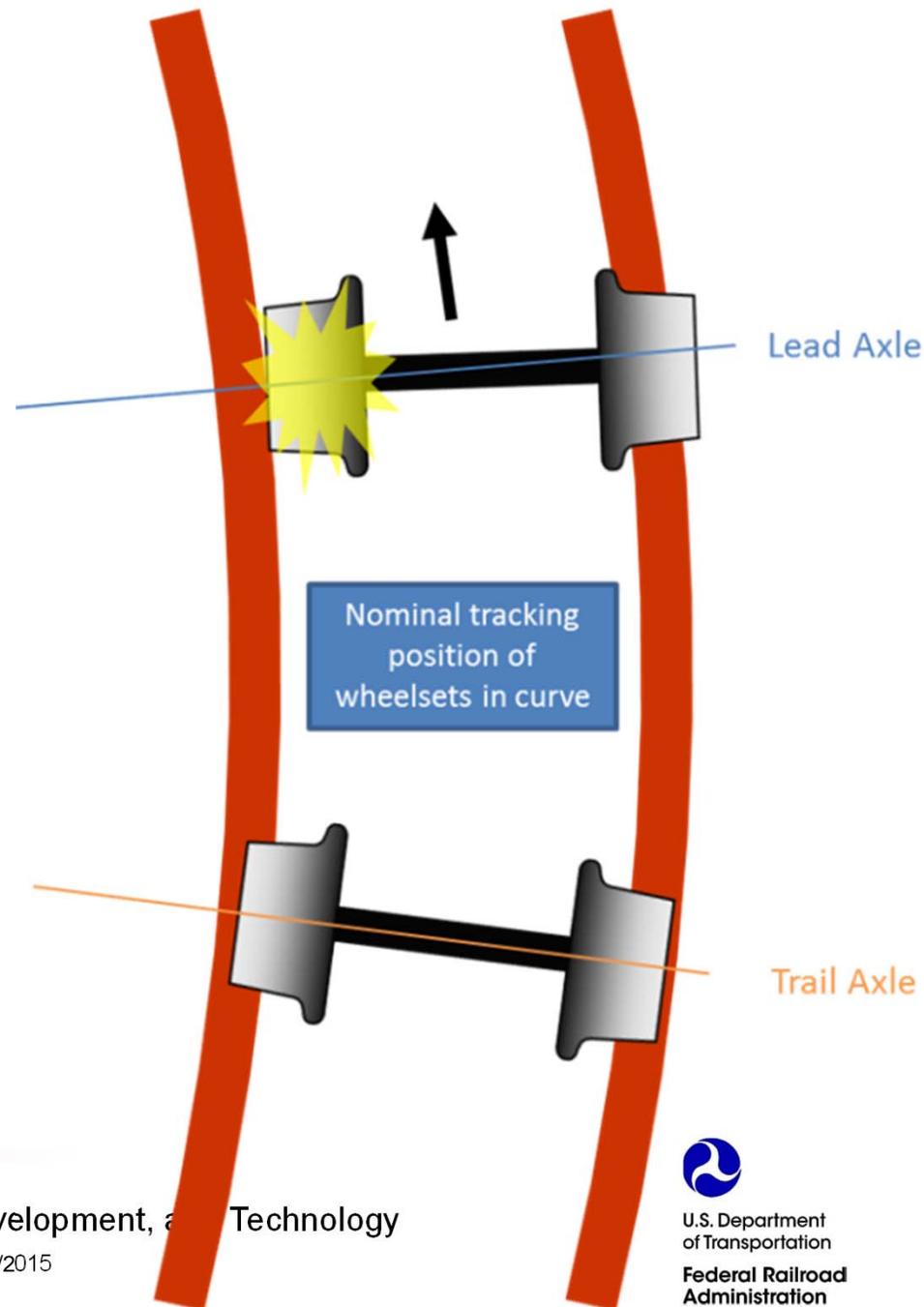
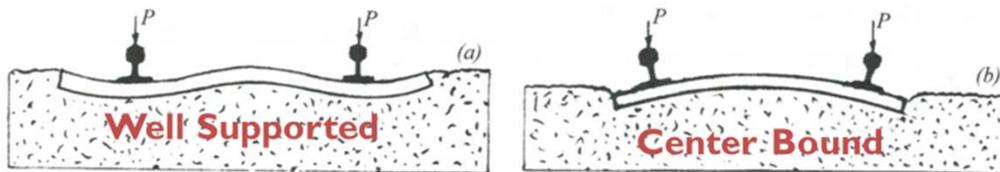
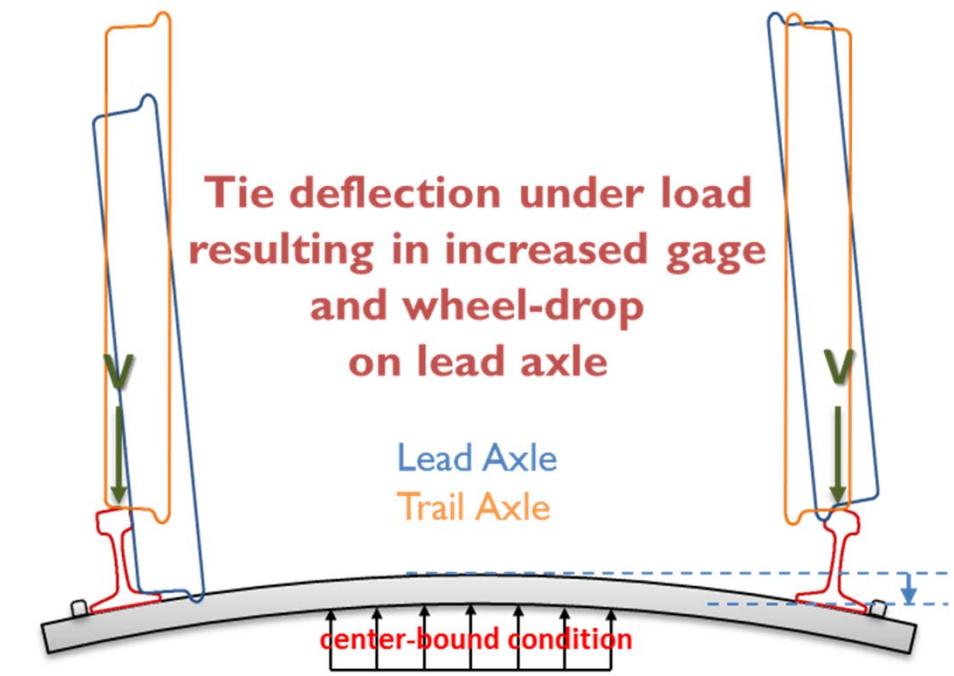
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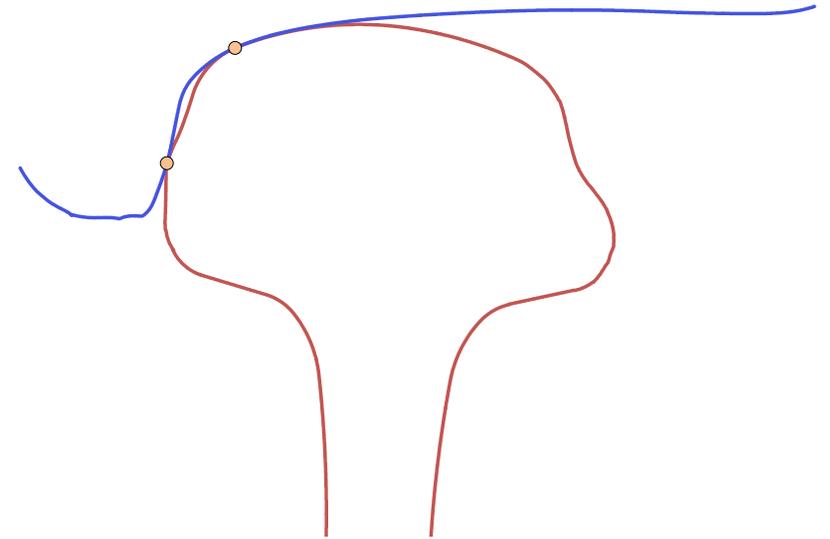
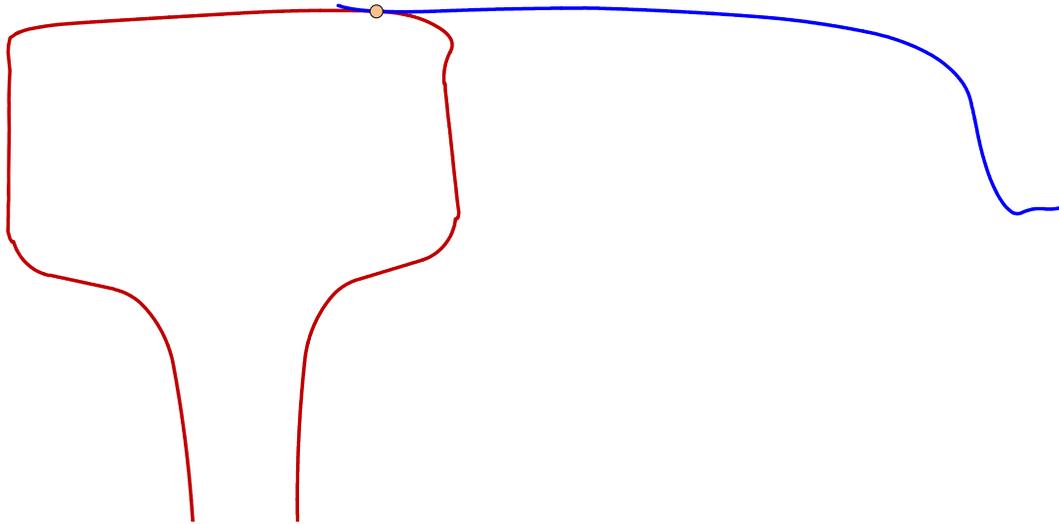
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Improved Track Modeling

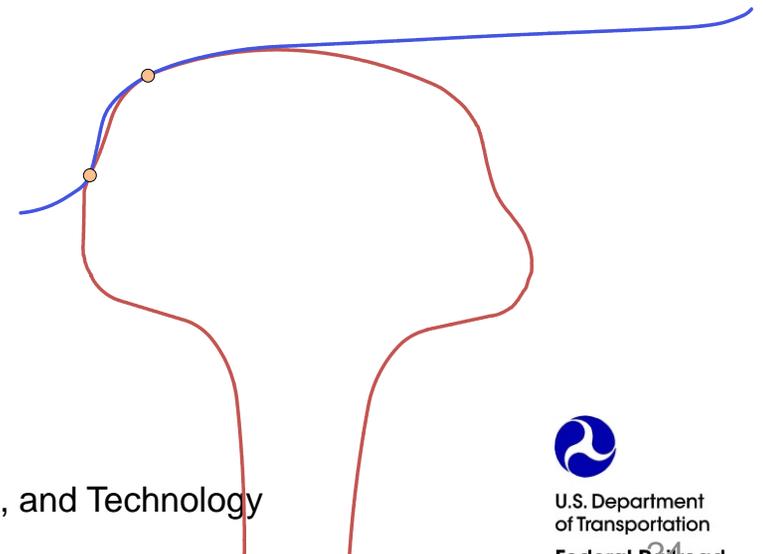
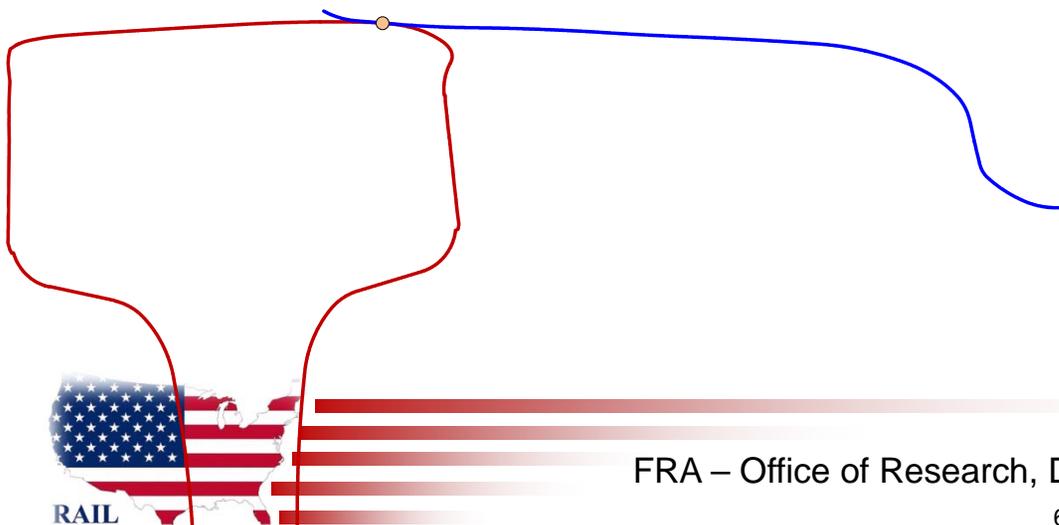


Improved Track Modeling

Axle 1



Axle 3



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Modeling challenges facing FRA

- **Further Examples of VTI Modeling Research Needs**
 - ❖ 3d Wheel/Rail Contact Geometry – For use in cases with varying rail profiles and studying low speed derailments in high degree curve
 - ❖ Improved Modeling of Rail Joints – Ability to put discontinuities in rail especially with poor support conditions
 - ❖ Modeling Wheel Flats and Out of Round Wheels
 - ❖ Improved Modeling of Special Track Work
 - ❖ Inclusion of sloshing dynamics of cargo – tank car

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