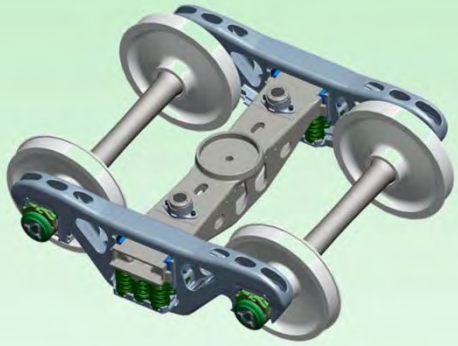
Basics of Vehicle Truck and Suspension Systems and Fundamentals of Vehicle Steering and Stability

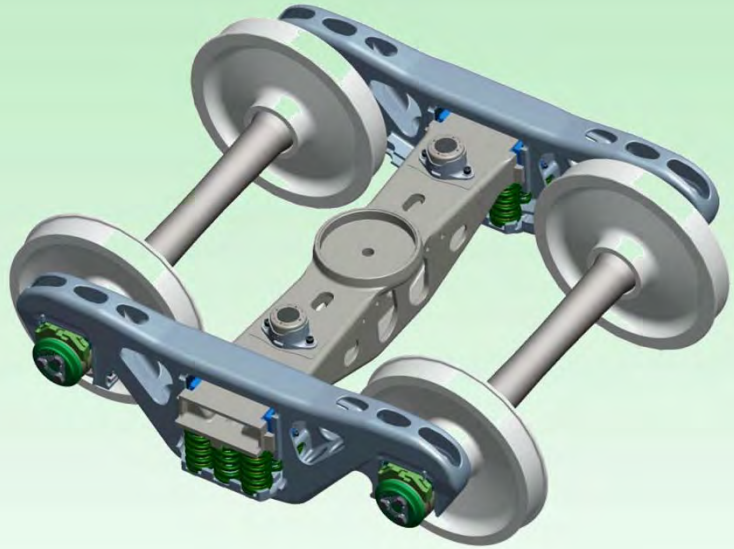


Ralph Schorr, PE
Senior Product Development Engineer

Vehicle/Truck Dynamicist

Course Agenda

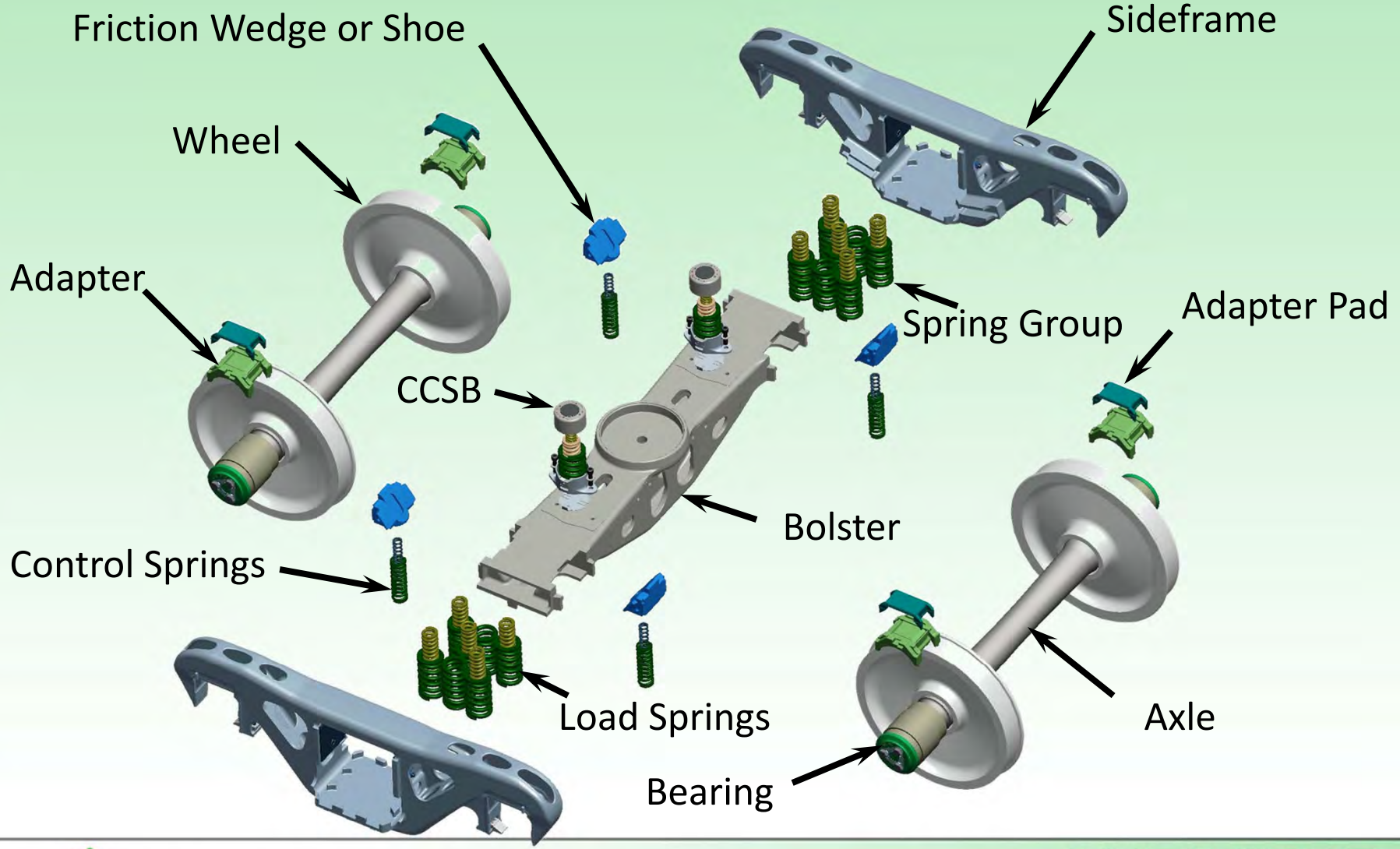
- Truck Nomenclature
- *Wheel/rail influences*
- Truck Dynamics
  - *Physics*
- Truck Types
- *AAR M-976*



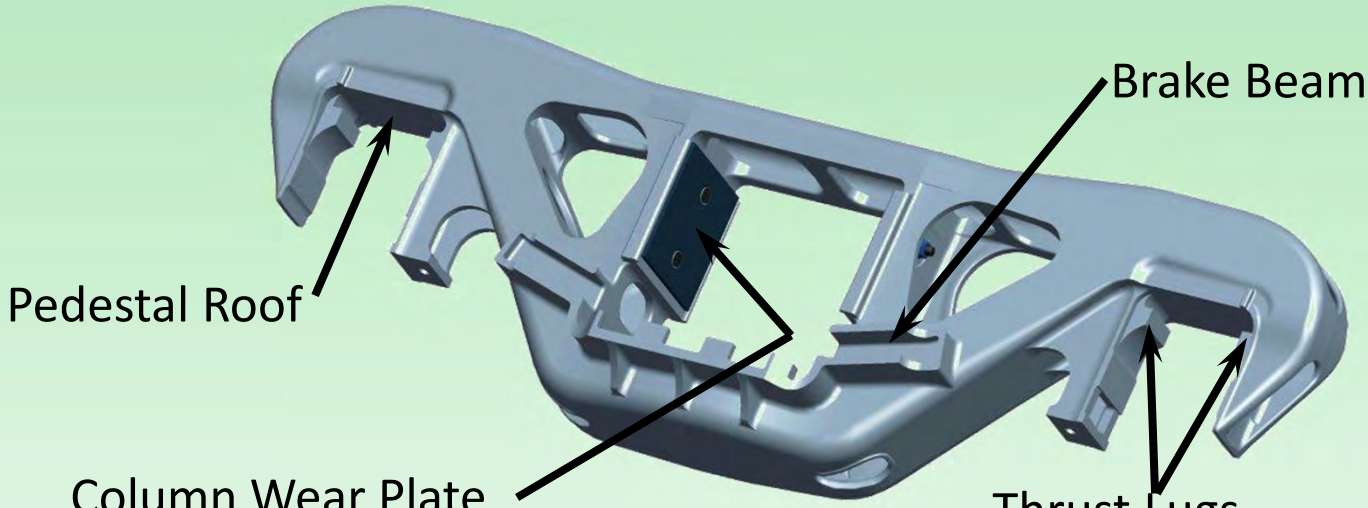
- *Truck Maintenance*

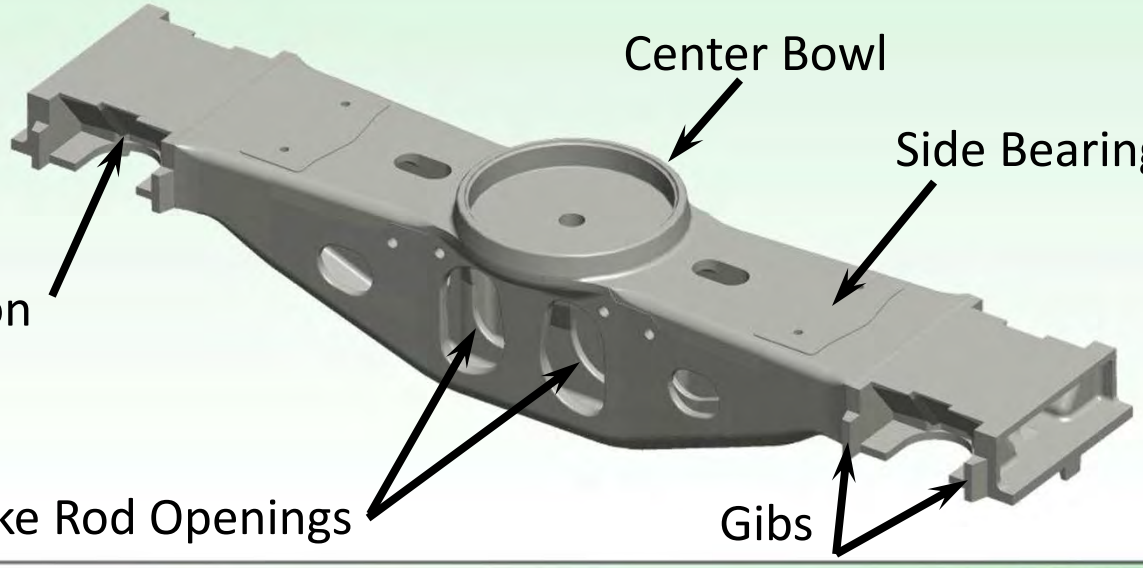
Truck Nomenclature (Bogie)

3-piece truck

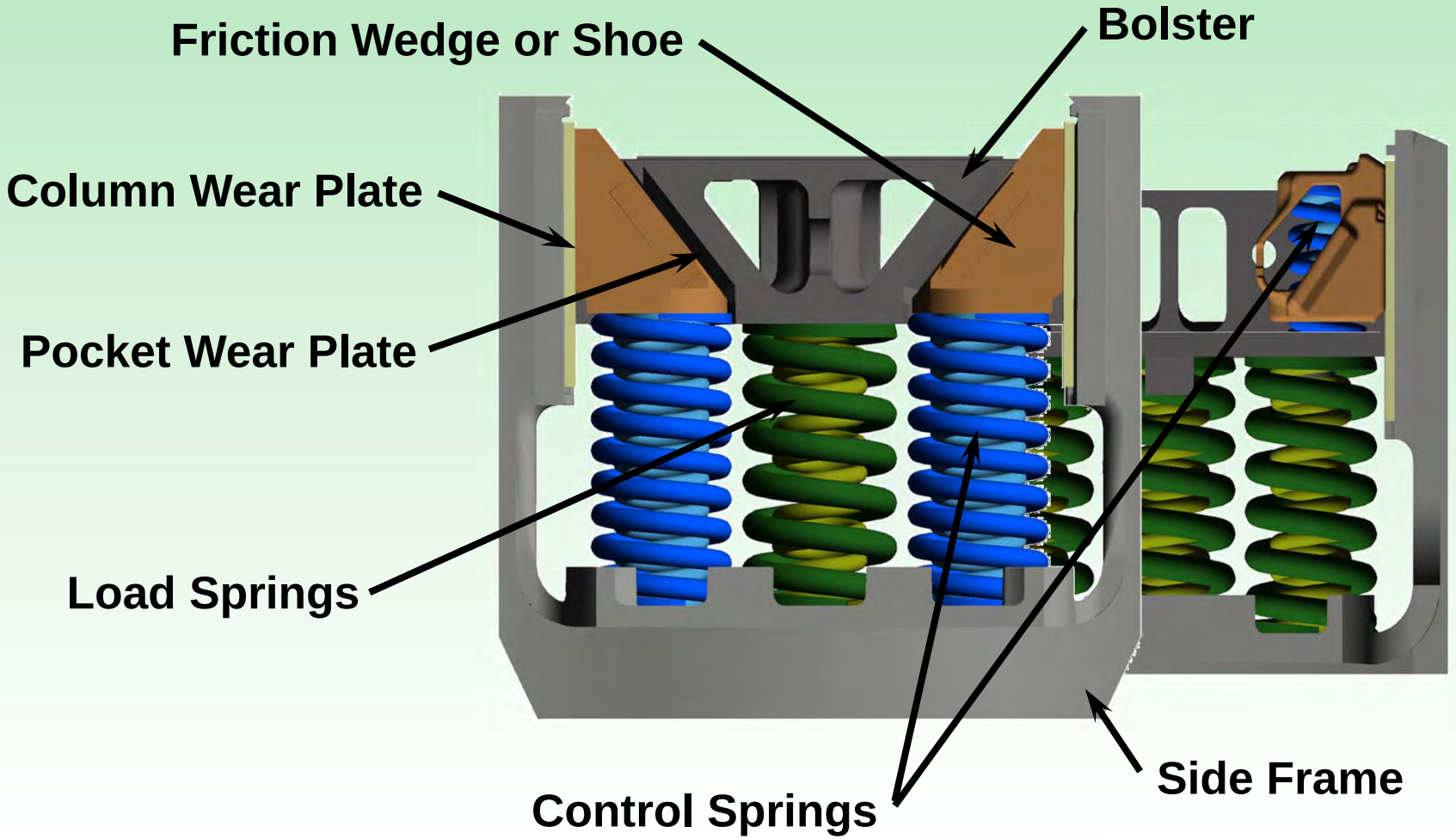


Truck Nomenclature



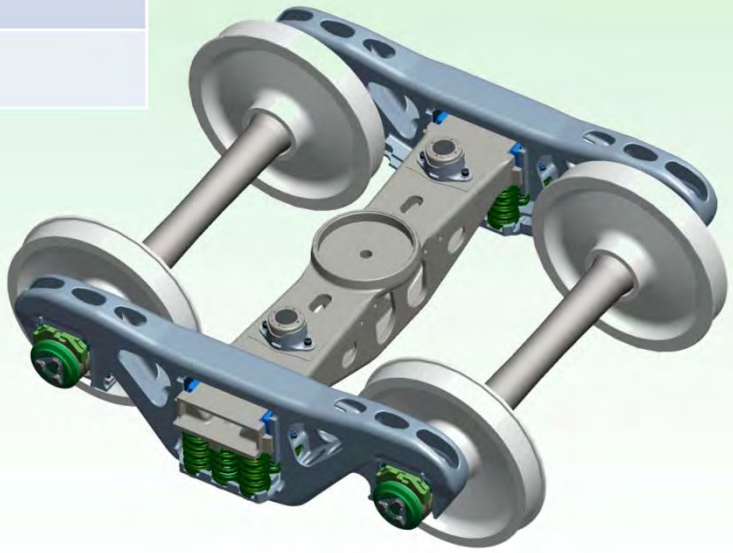


Suspension Nomenclature

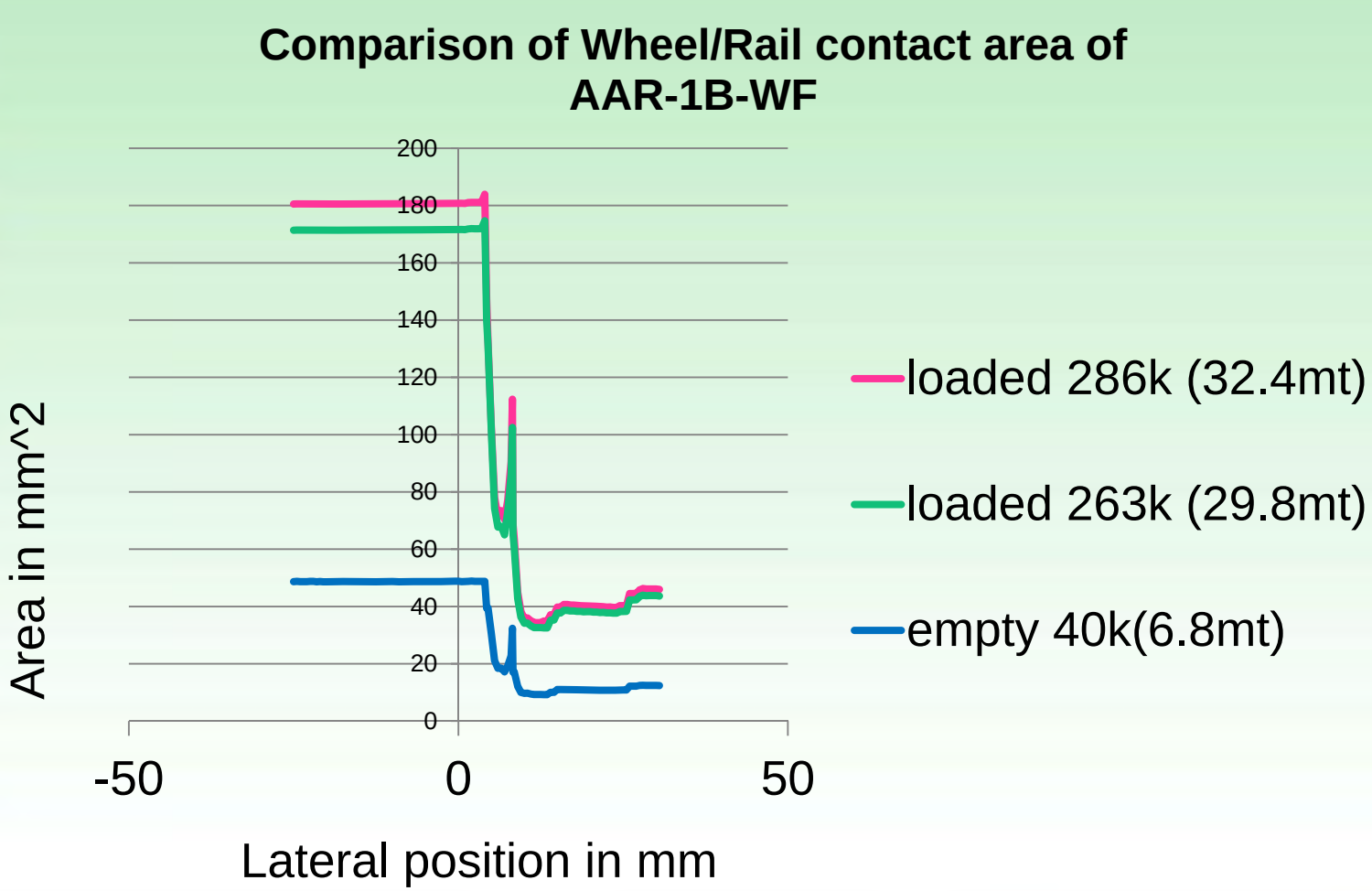


North American Freight Car Systems

Capacity Tons	GRL Lbs.	Bearing Size	Wheel Diameter Inches
70	220,000	Class E	33
100	263,000	Class F	36
110	286,000	Class K	36
125	315,000	Class G	38

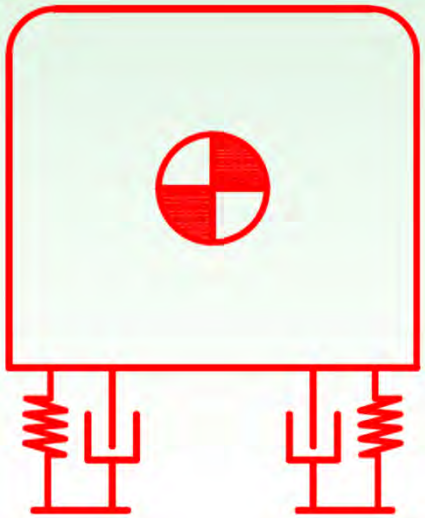


Contact Patch area

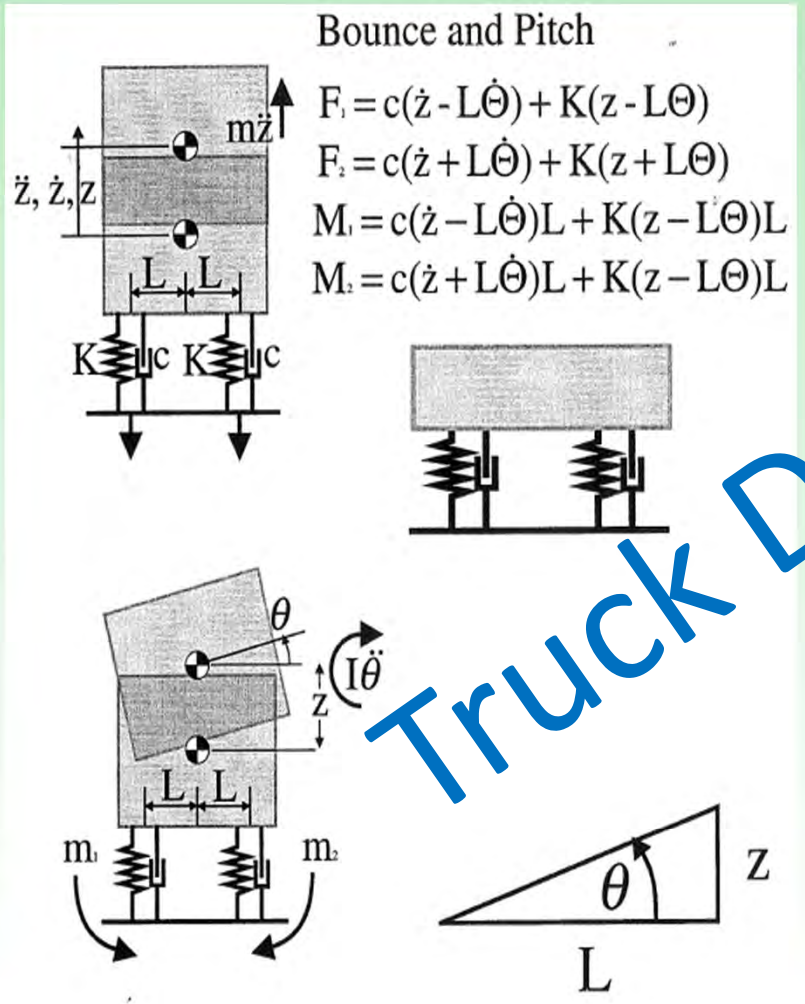


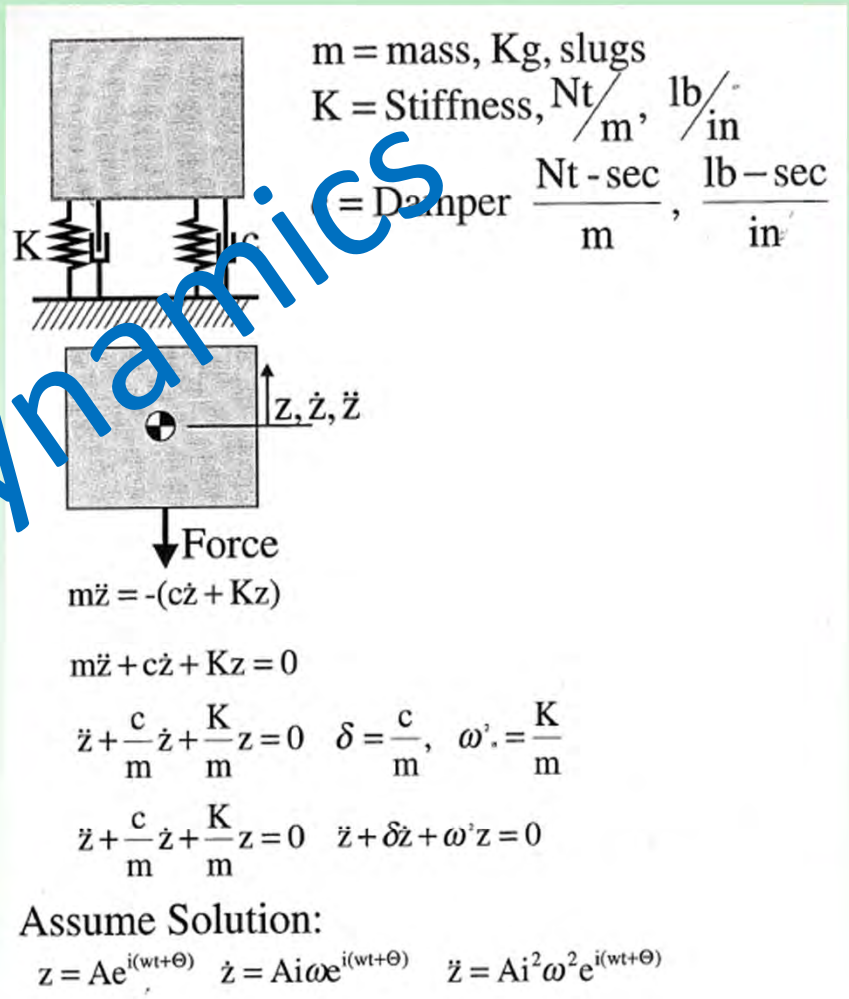
Dynamic Influences

- Speed
- Wheel to Rail Contact
- Track Input
- Mass/Inertias (Car Body, Truck Components)
- Friction
- Spring Suspension
- Suspension Dampening



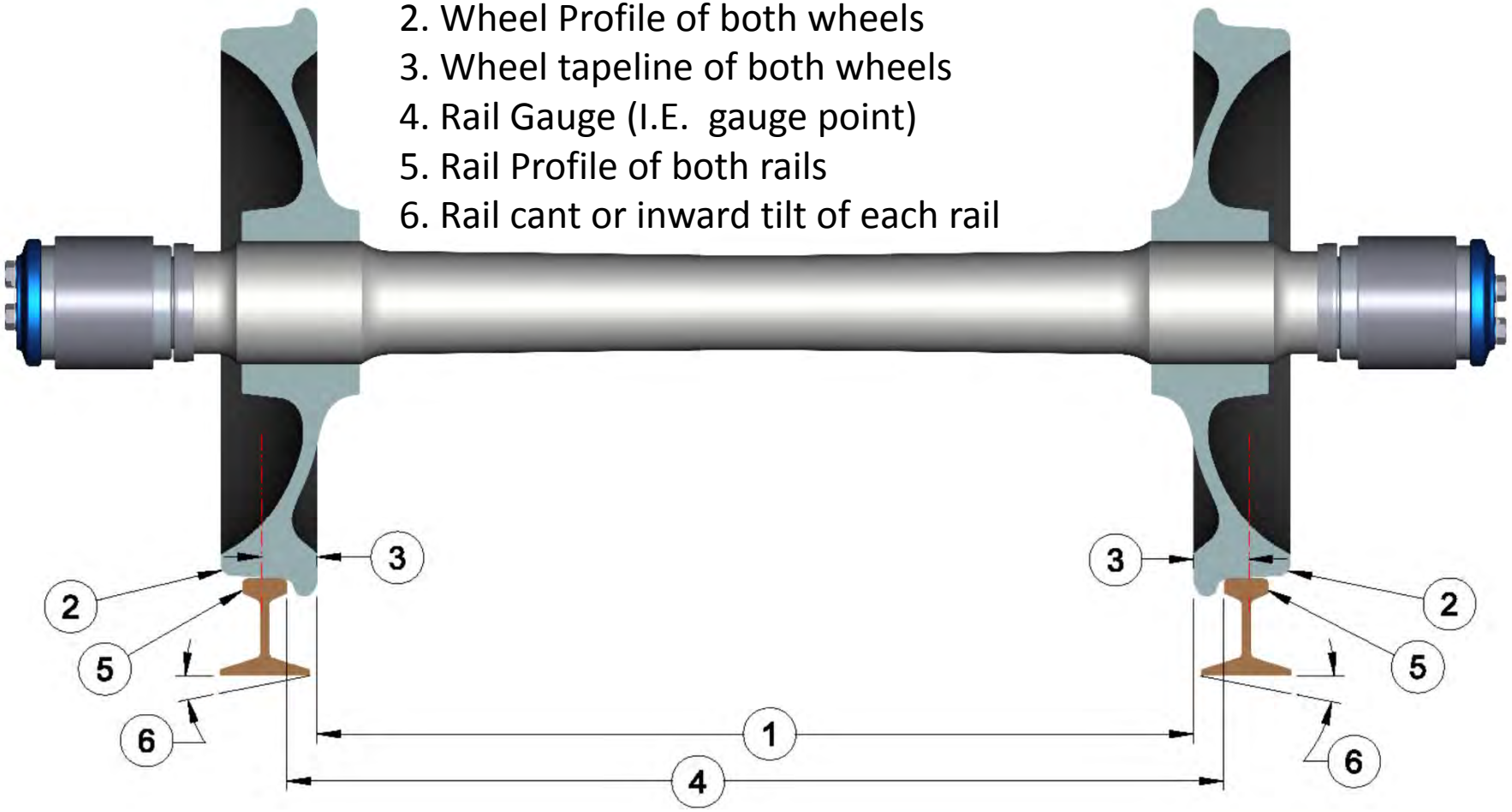
Multimode Dynamics Software





Critical Attributes of the Wheel/Rail

1. Wheel set back-to-back dimension
2. Wheel Profile of both wheels
3. Wheel tapeline of both wheels
4. Rail Gauge (I.E. gauge point)
5. Rail Profile of both rails
6. Rail cant or inward tilt of each rail

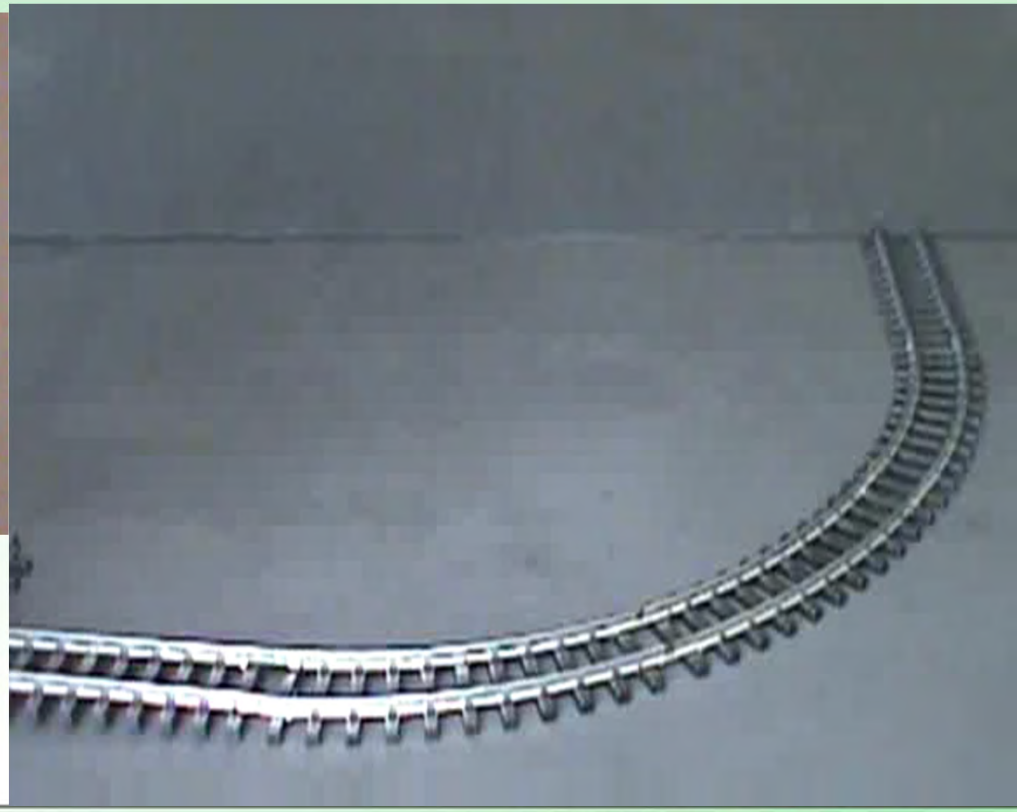


Why do wheels have Conicity?

1:12 taper 1:6 taper cylinder

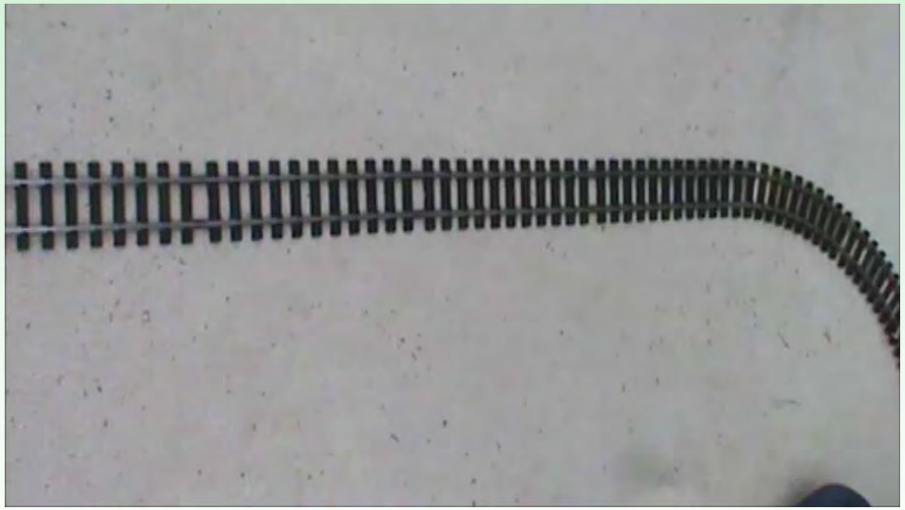
EC = 0.083 EC = 0.167 EC = 0

*Curtis Urbin of TTCI



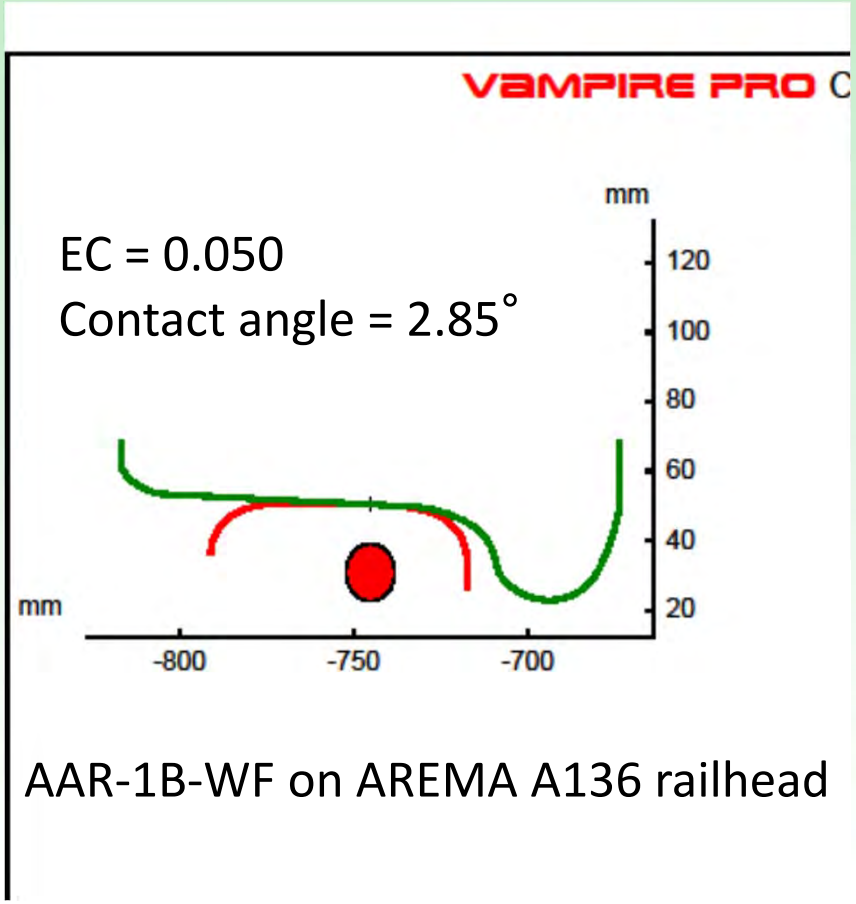
Wheels conicity in service

- Transit cars = 1:40
- Freight cars = 1:20



Conicity and Rolling Radius

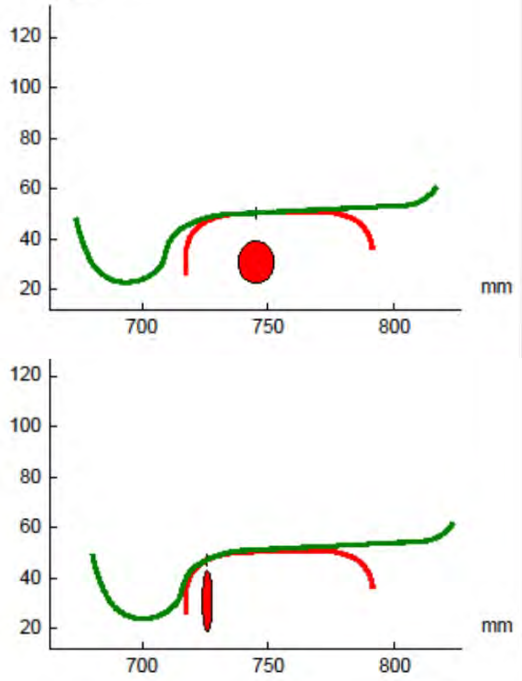
- Slope angle at point of contact
- Rolling Radius Difference
- Effect of Wear on rail and wheel



AAR-1B-WF on AREMA A136 railhead

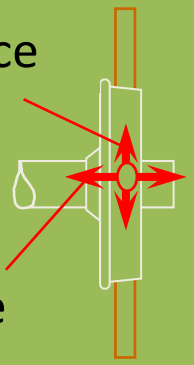
Hertzian Contact Patch - Creep theory

AAR-1B-WF
on new 136# rail



Contact Patch Issues:

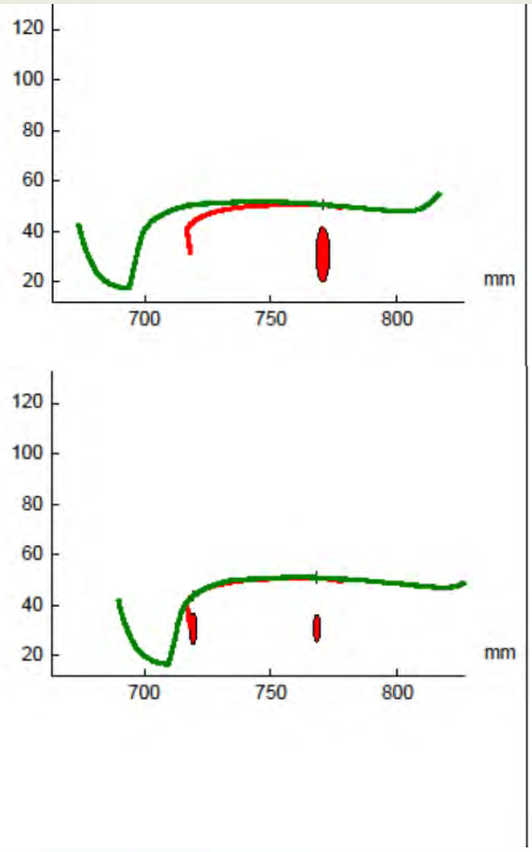
Steering Force



Lateral Force

* Creep theory

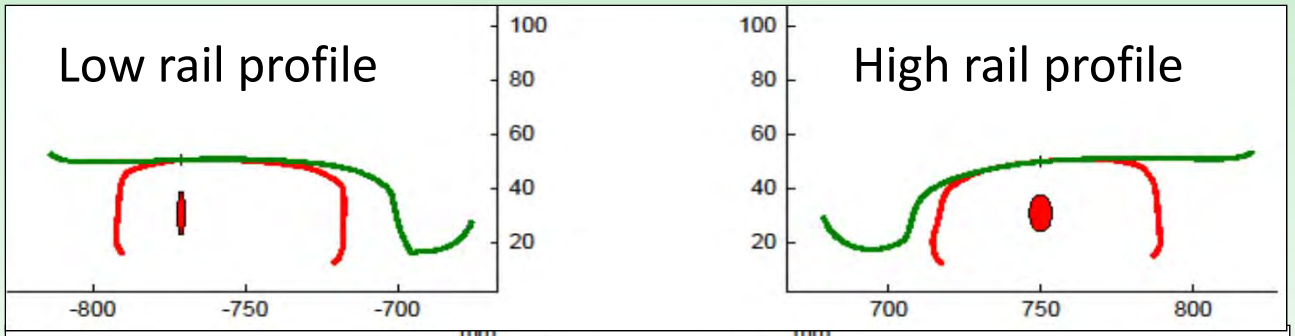
4mm hollow wheel
on TTCI ttt track



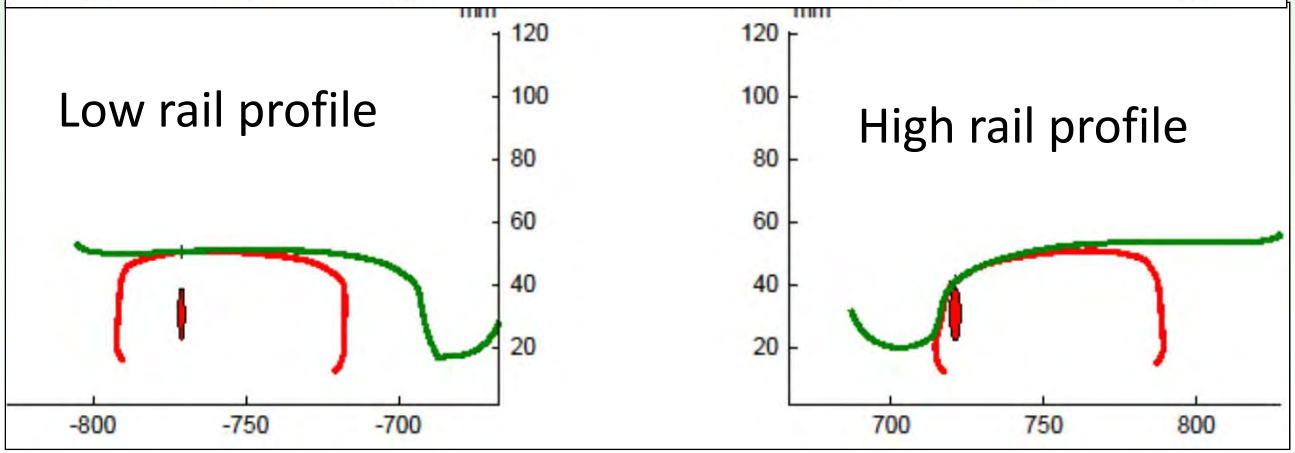
Contact Patch in curves

TPD rail profile with “average” worn wheel

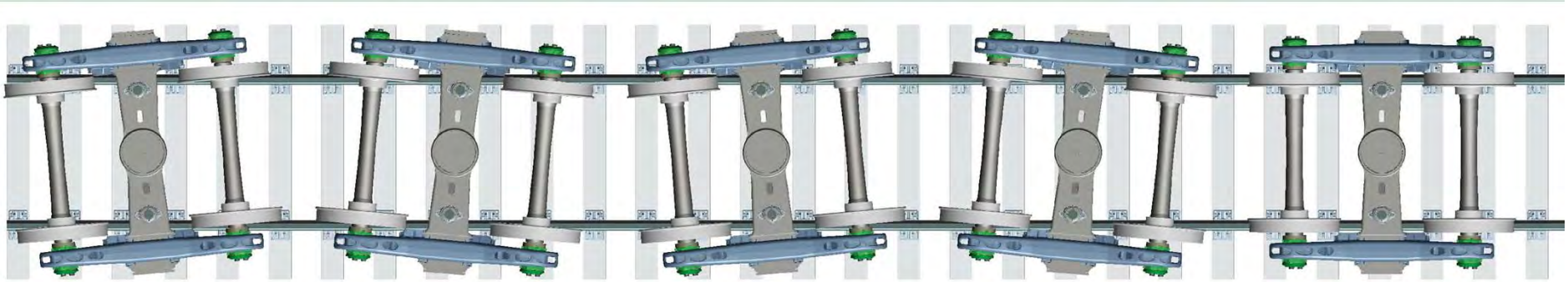
Angle of high rail contact = 6.65˚
RRD = -0.11 mm

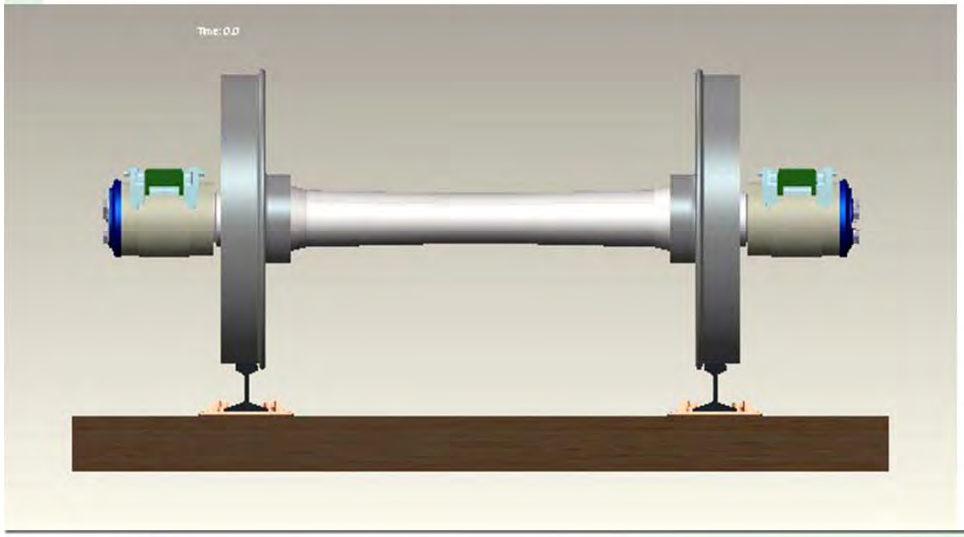


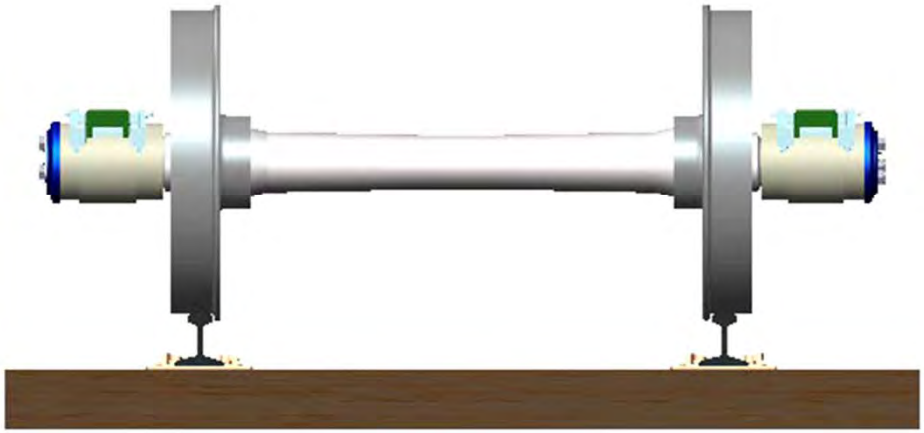
Angle of high rail contact = 42.26 ˚
RRD = 10.74 mm



Wheelset instability

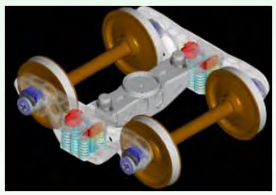


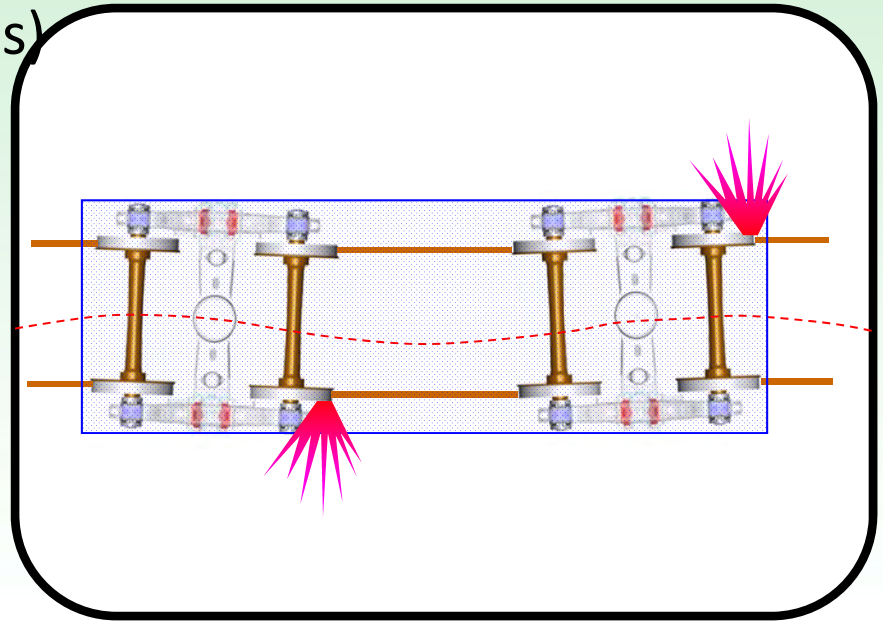




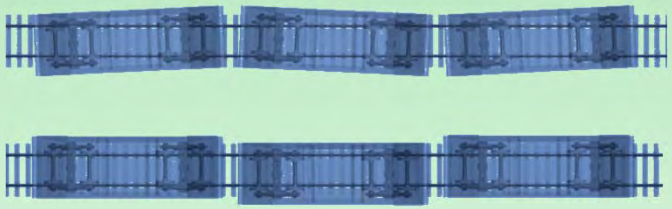
Truck Hunting

- High Speed
- Typically worse for empty cars
- Rail friction (~ 8 mph)
- Causes wheel wear and lading damage
- Measured in lateral gs rms (0.13gs)

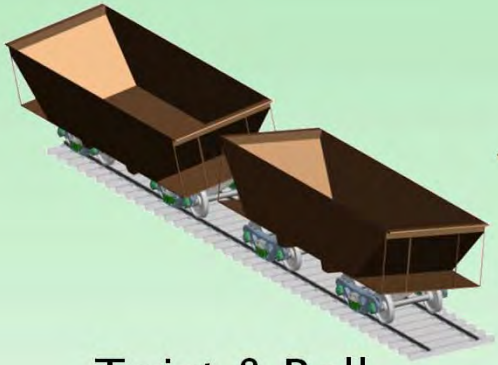




Truck Performance Modes



Yaw & Sway
Car / Suspension Specific

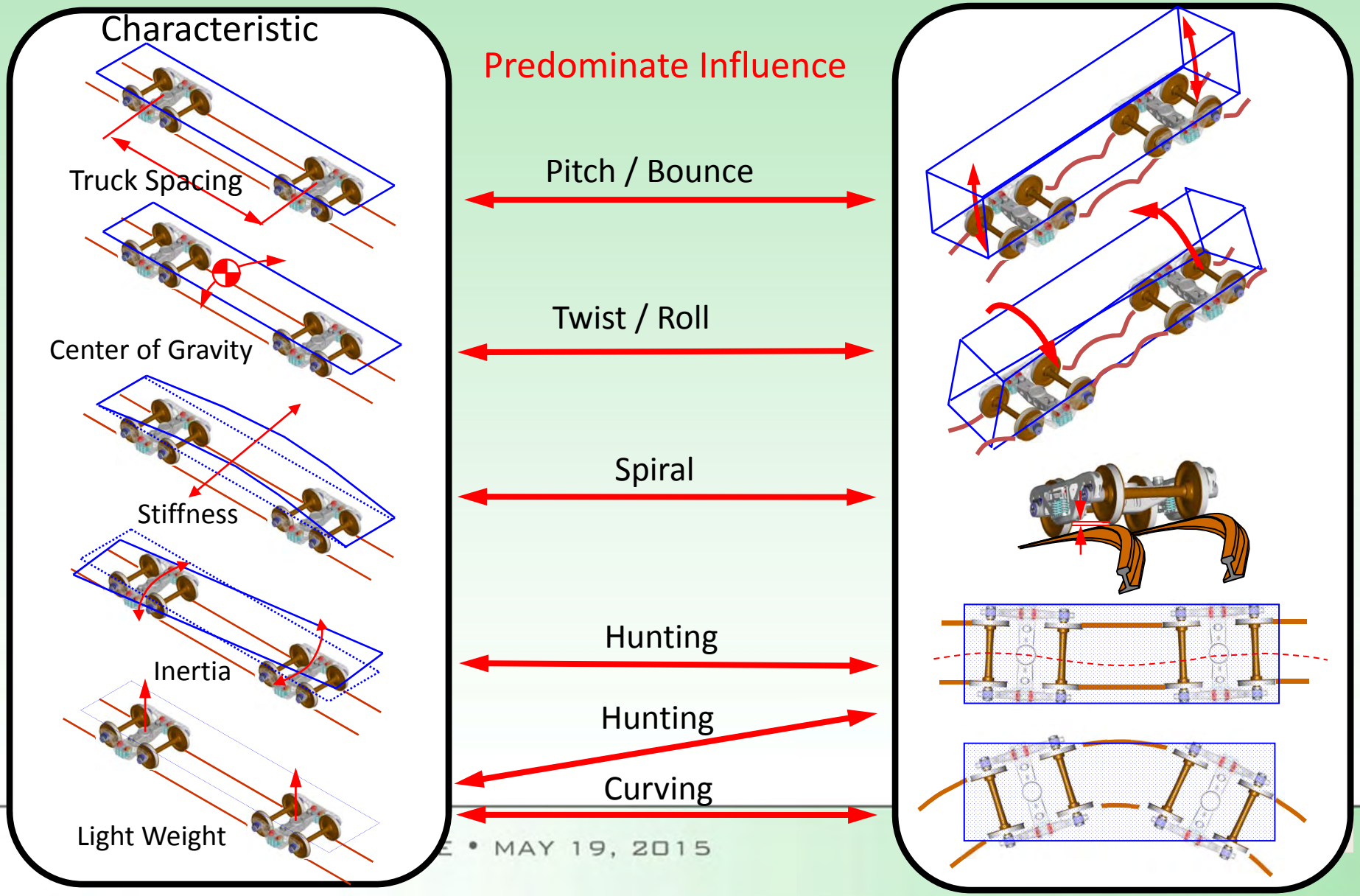


Twist & Roll
15-25, 50-60 mph

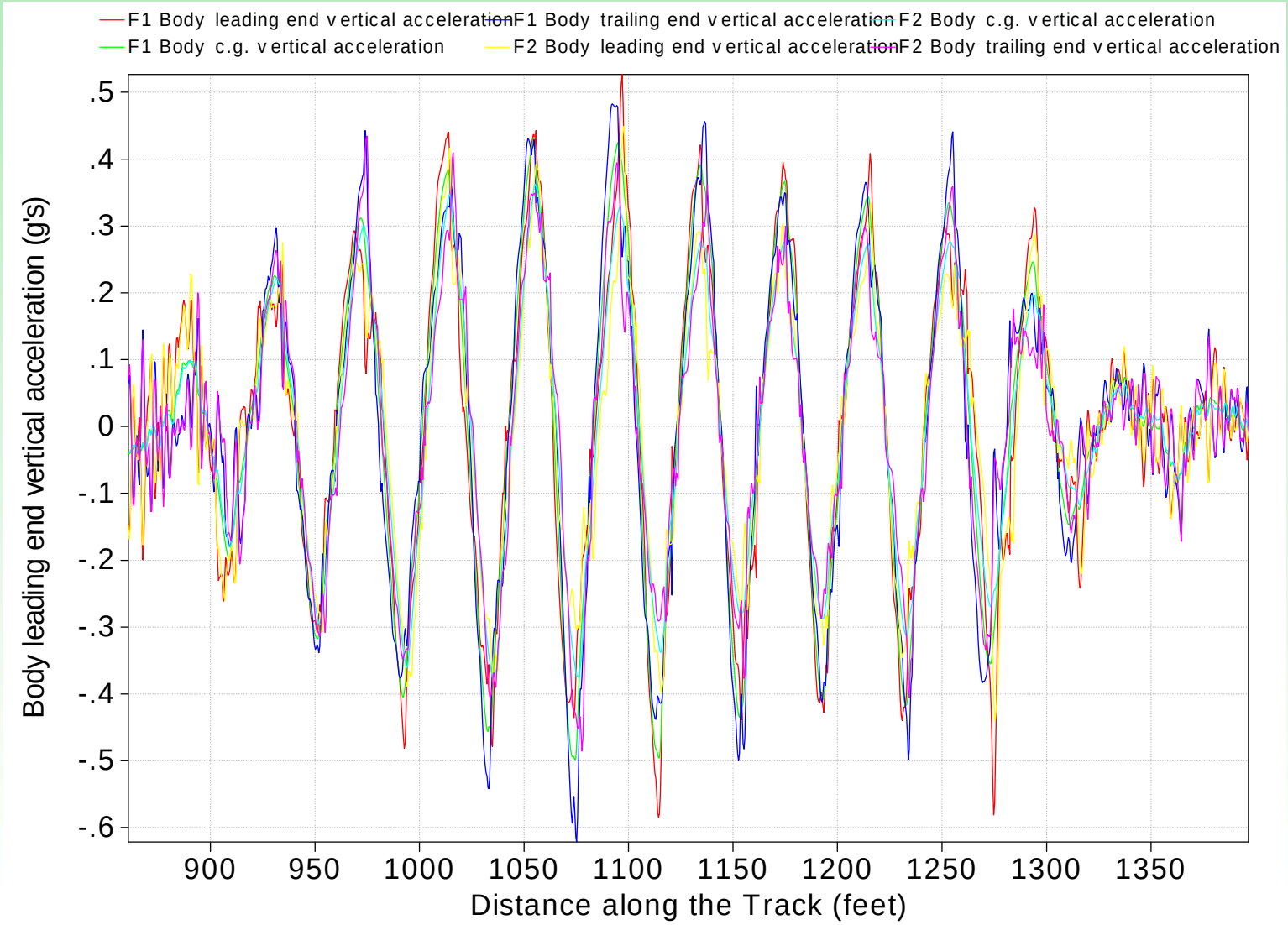
Pitch & Bounce
50-70 mph

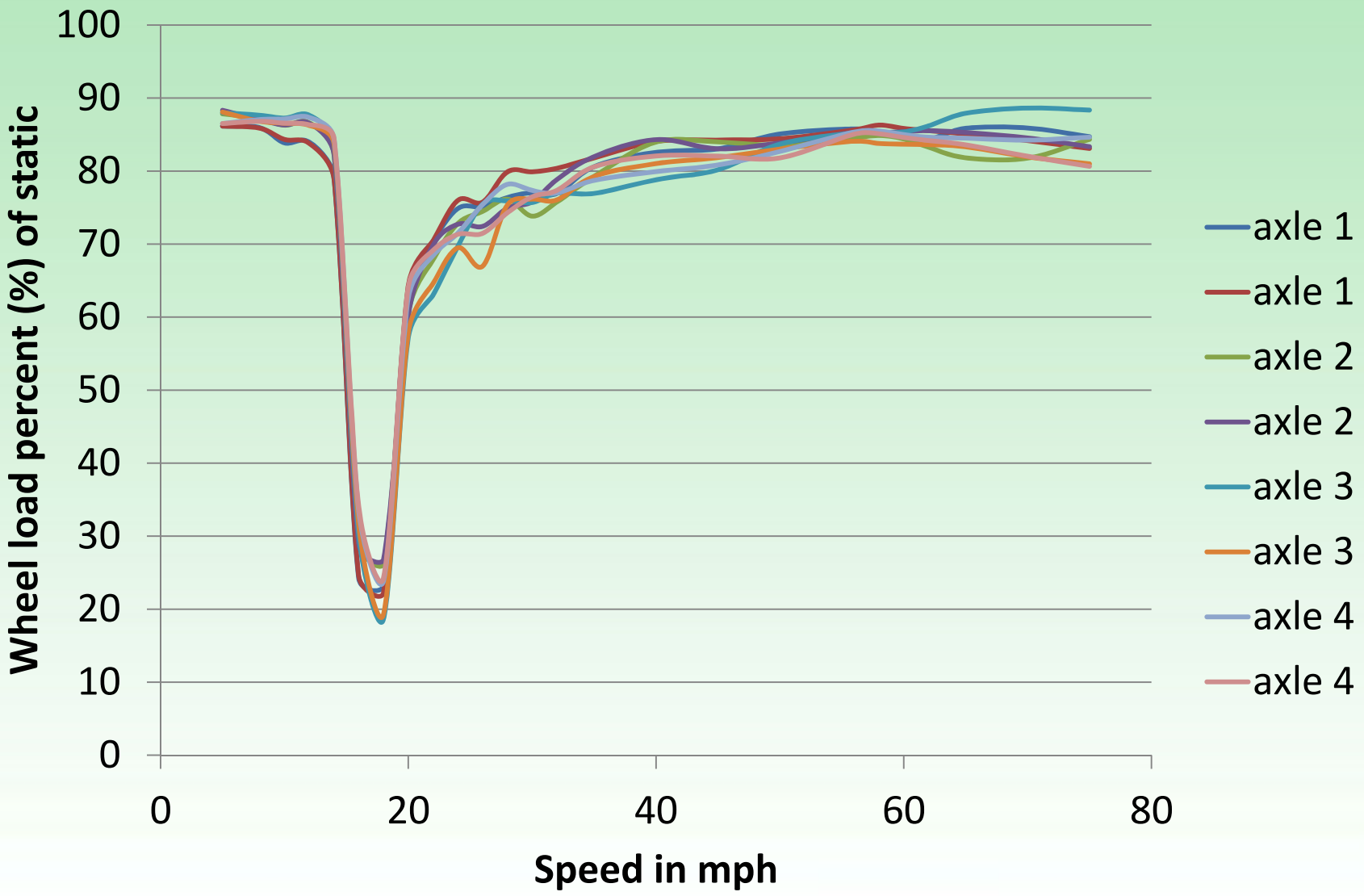
Truck Hunting
Truck Warp, Truck Rotation, Wheelset Movement
40+ mph

Carbody Interaction Details

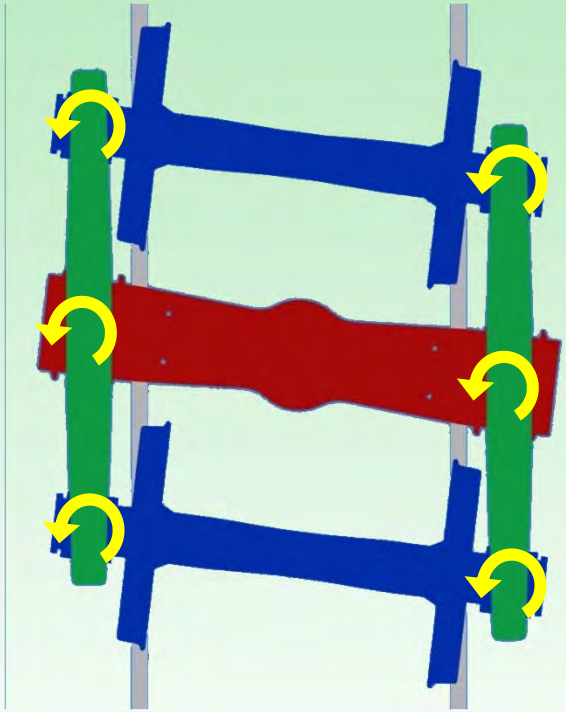


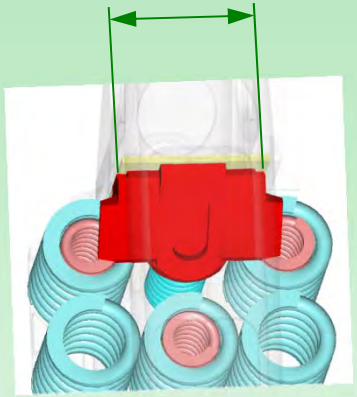
Hopper Car on Pitch and Bounce track



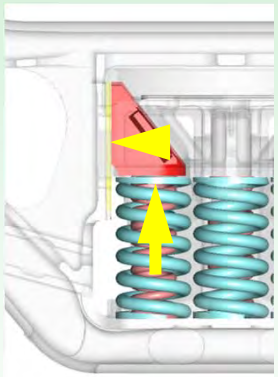

Empty 286k Grain car on Twist and Roll track
Wheel load percent (%) of static
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
Speed in mph
axle 1
axle 1
axle 2
axle 2
axle 3
axle 3
axle 4
axle 4

Truck Interaction Details





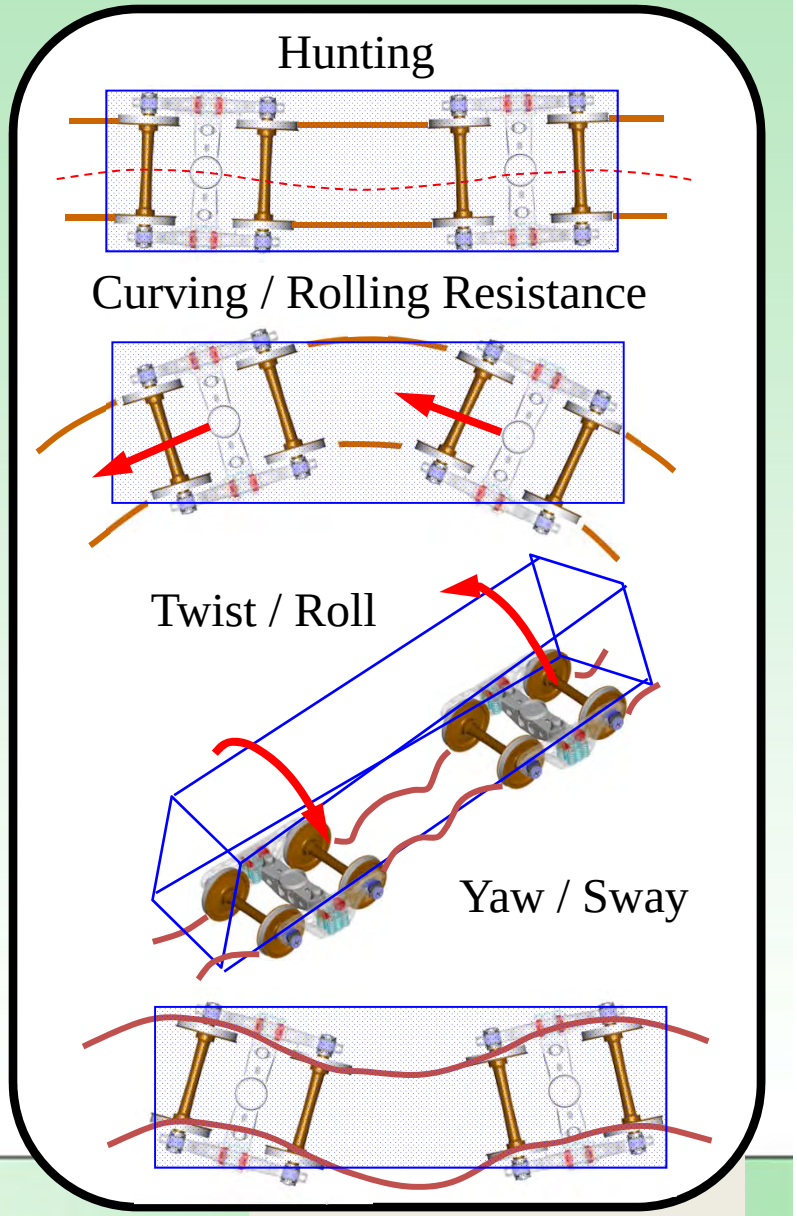
Shoe Width



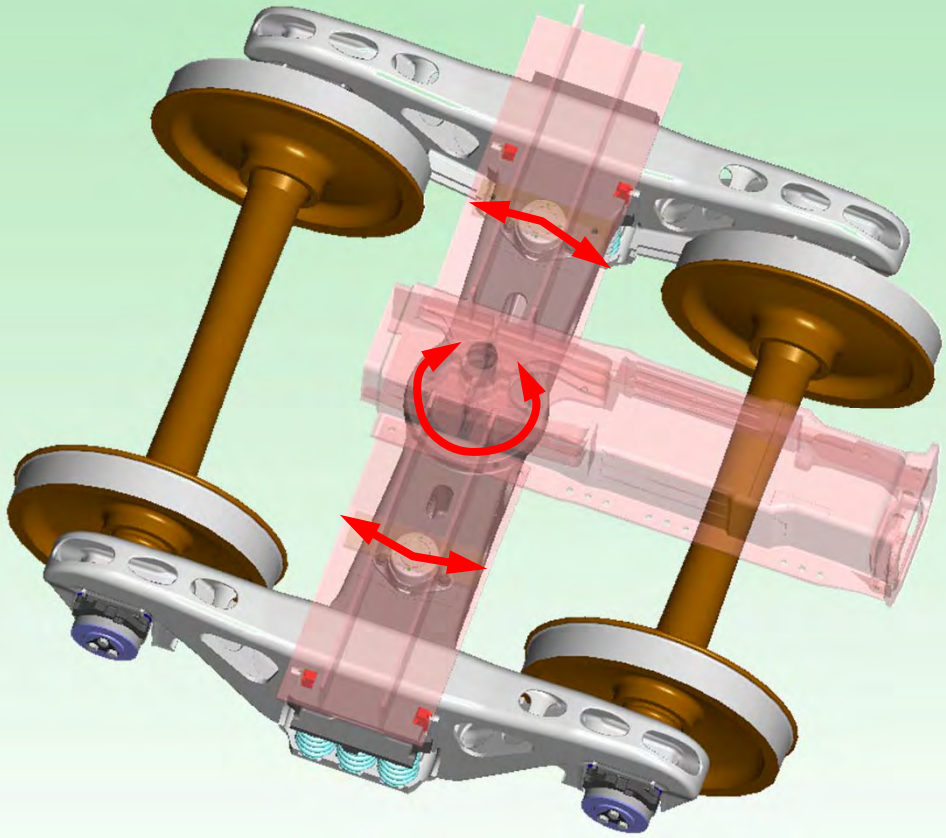
Shoe Force

Warp Stiffness

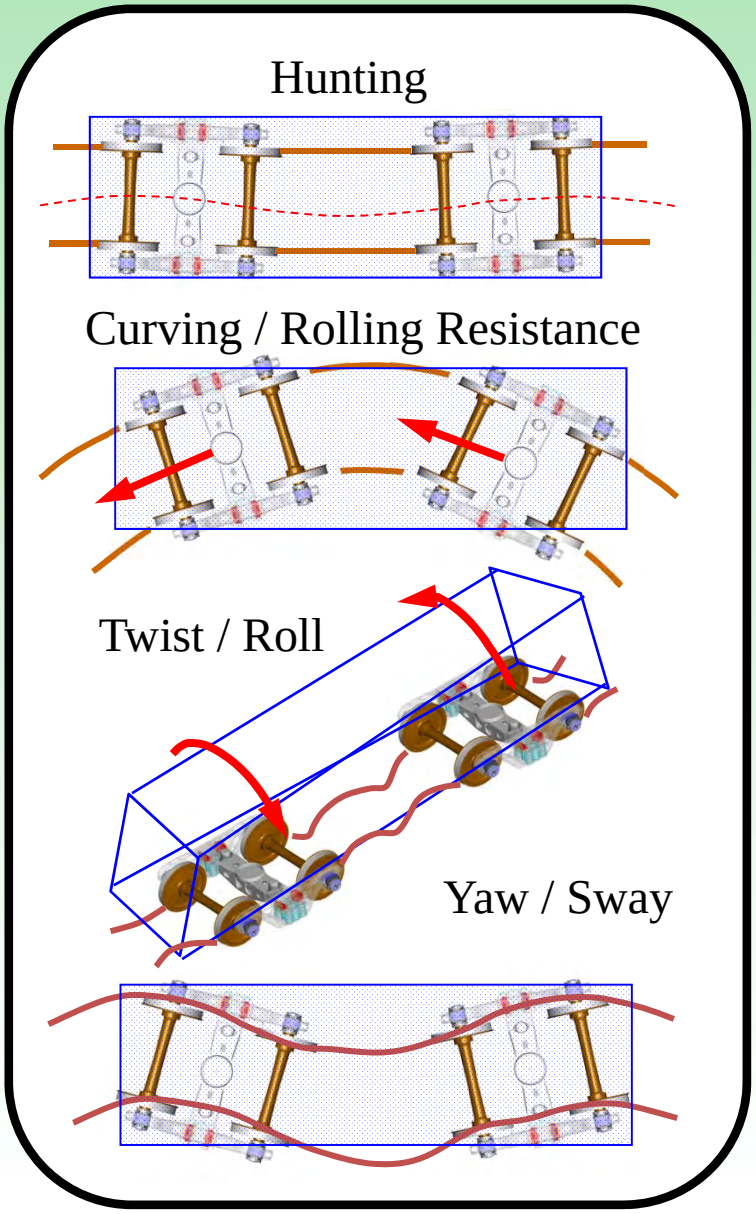
The warp stiffness design is controlled by the shoe width and force



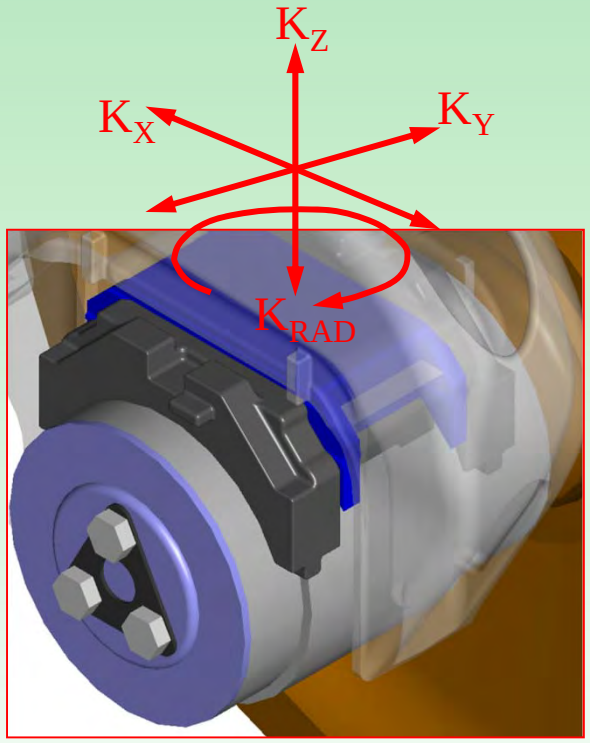
Carbody / Truck Interaction Details



Carbody Bolster Interface
Side Bearing / Center Plate friction design accommodates these regimes and must remain consistent

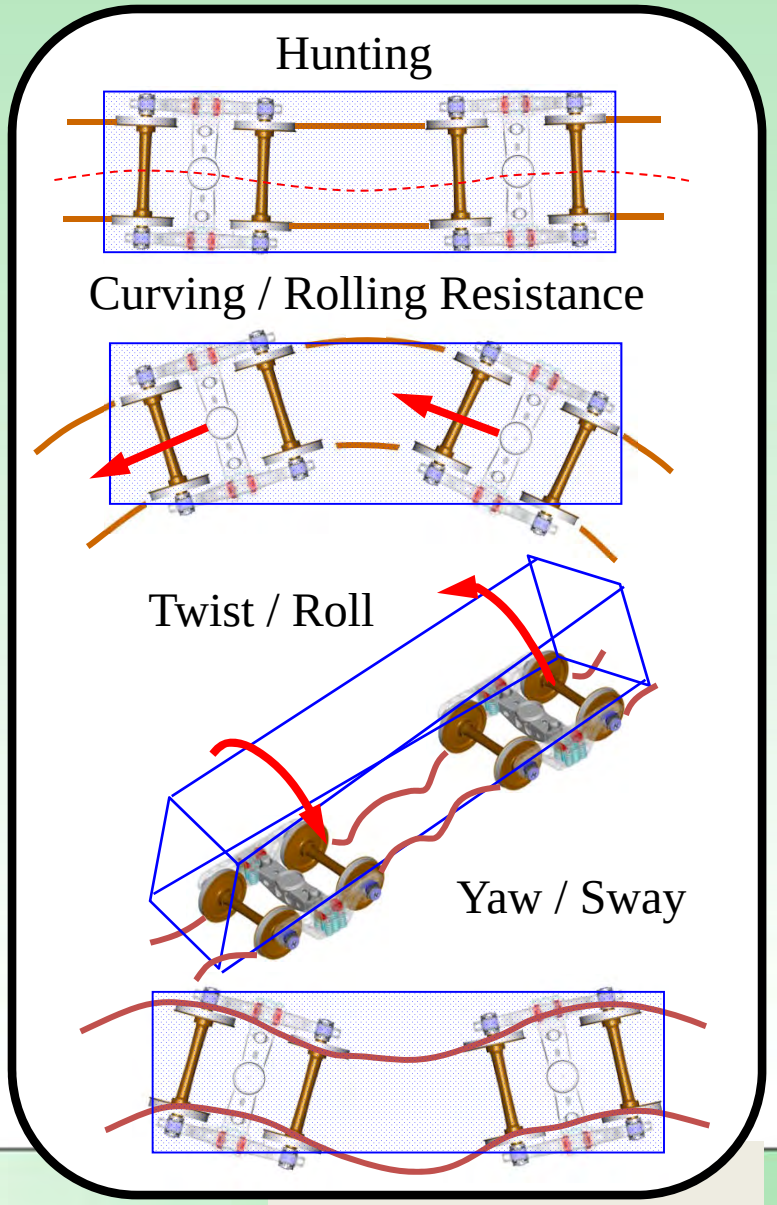


Truck Interaction Details

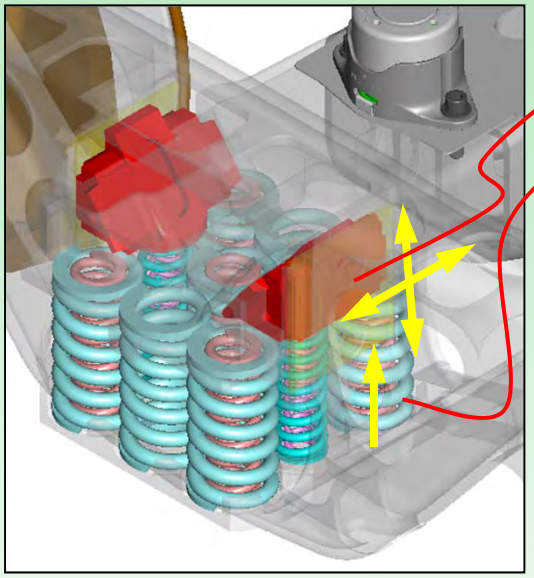


Passive Steering

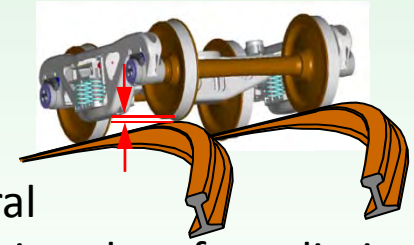
- Provides wheelset alignment to reduce rolling resistance
- Designed stiffness enhances performance for these regimes



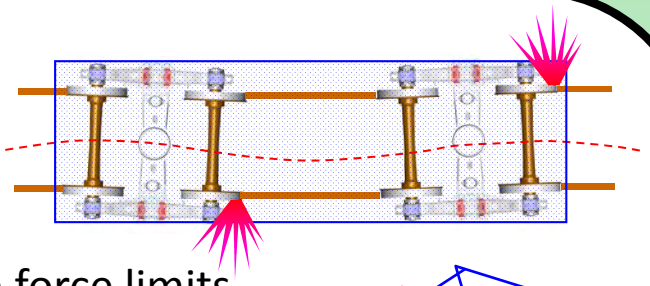
Truck Interaction Details



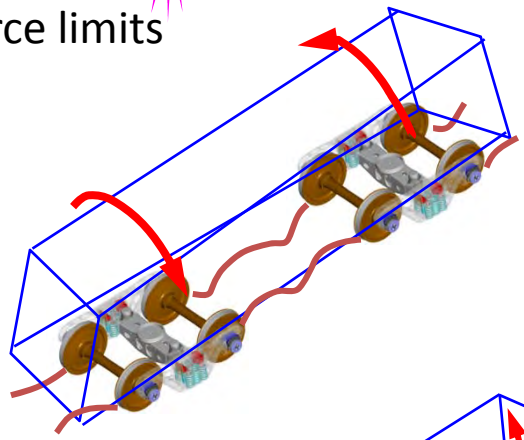
- Friction Shoe
- Springs



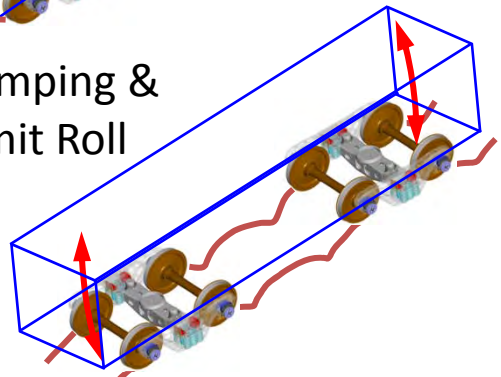
Spiral
Friction shoe force limited to prevent wheel unloading



Hunting
Friction shoe force limits warp

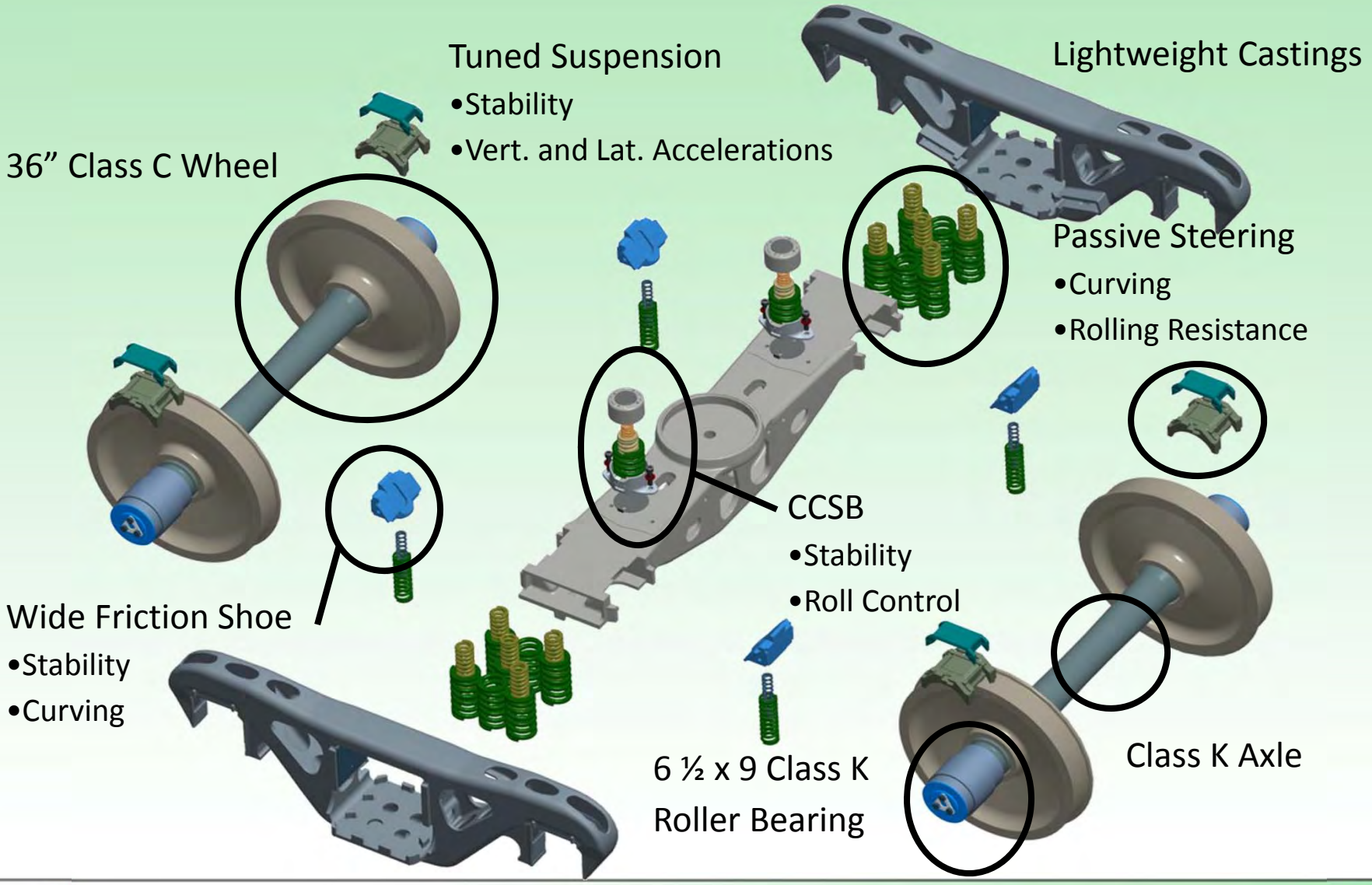


Twist / **Roll**
Tuned friction shoe damping & suspension stiffness limit Roll



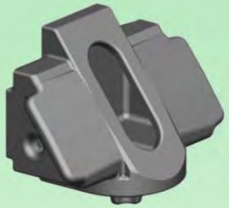
Pitch / Bounce
Tuned friction shoe damping & suspension stiffness limit Pitch / Bounce

Motion Control® Features M-976



M-976 Friction Shoes

- Motion Control® and SSRM
- Ridemaster
- Super Service Ride Control
- S-2-HD Split Wedge
- S-2-E





Shoe Types

ASF Shoe Design (MoCo,SSRC)

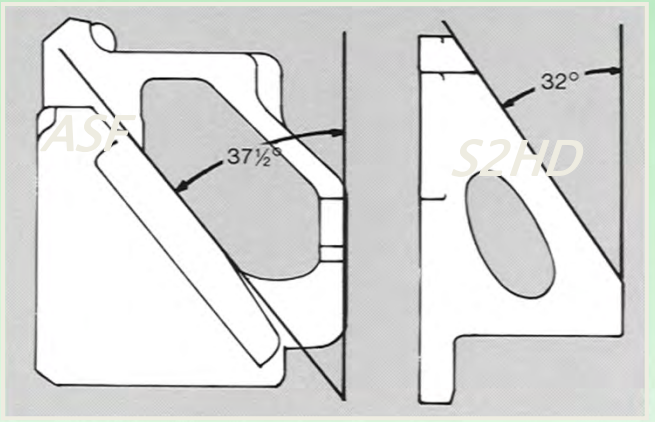
- 37.5° Angle
- 30” Slope Radii, Shaped Slope
- Steel Shoe

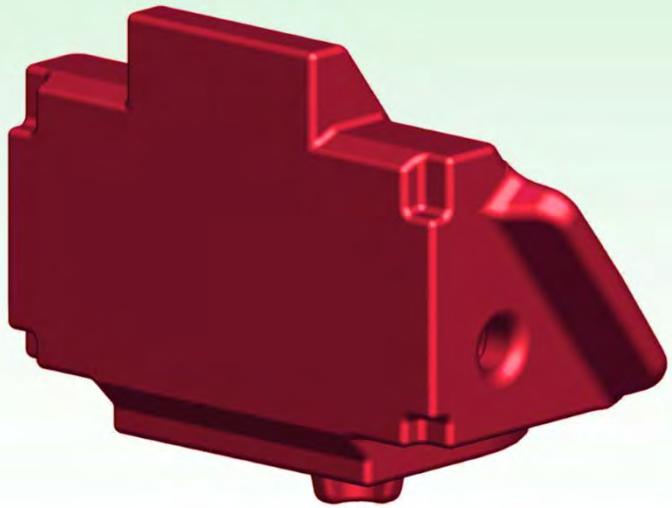
Accommodates:

- Bolster/Side Frame Rotation
- Part Variation - Casting, Shoe

Provides:

- Shoe Stability - Roll and Sway
- Warp Stiffness - Edge Contact
- Smooth Action
- Long Suspension Life

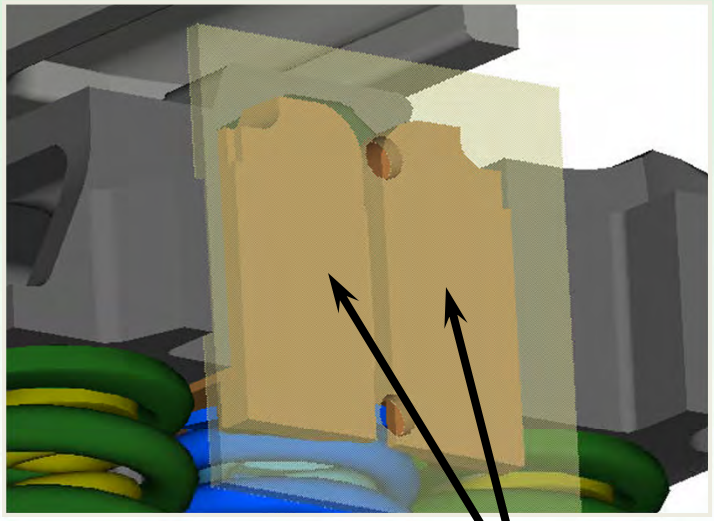




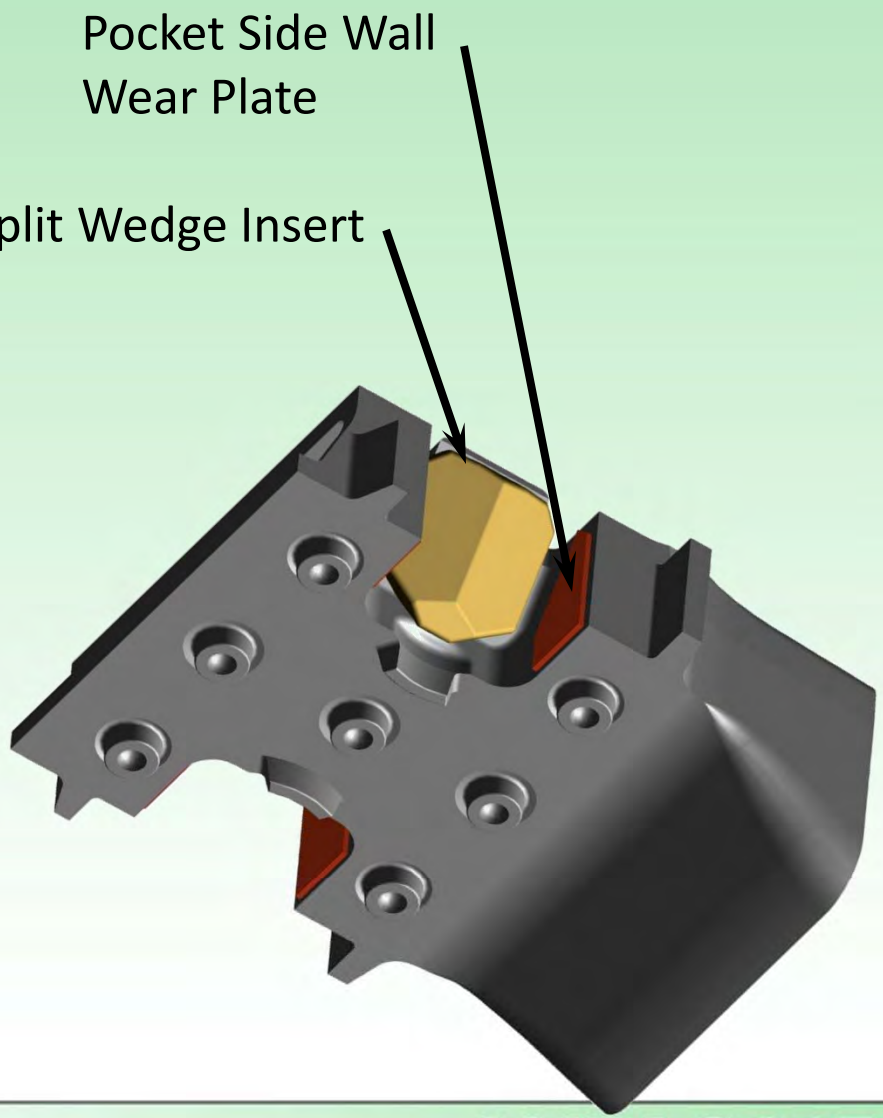
Shoe Types

S2HD Shoe Design

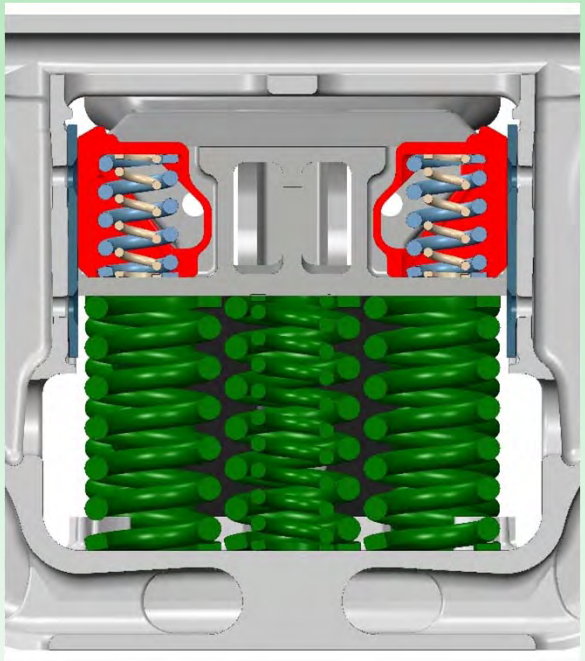
- 32° Angle
- Split Wedge
- Iron Shoe



Split Wedges

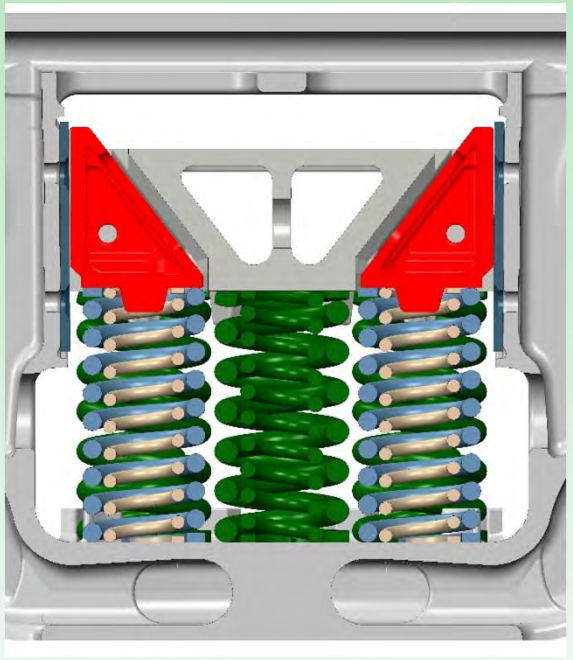


Suspension Design



Constant

-ASF Ride Control
-ASF SSRC
- Buckeye XC-R
- Meridian C-1, Wedge Lock



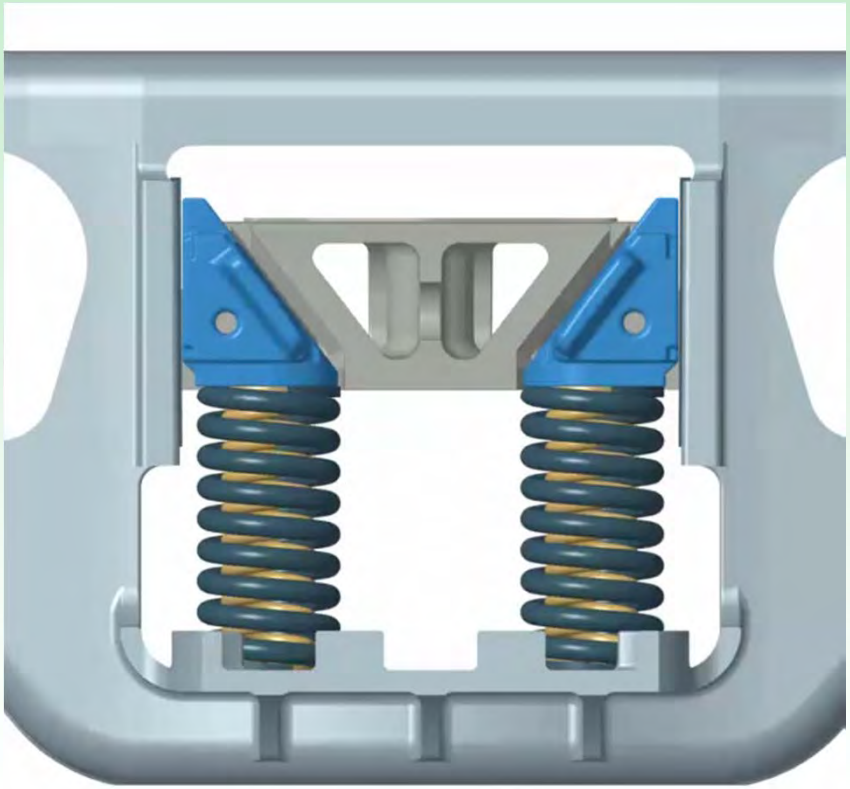
Variable

-Motion Control
- ASF Ridemaster
-Swing Motion
-Barber S-2-HD

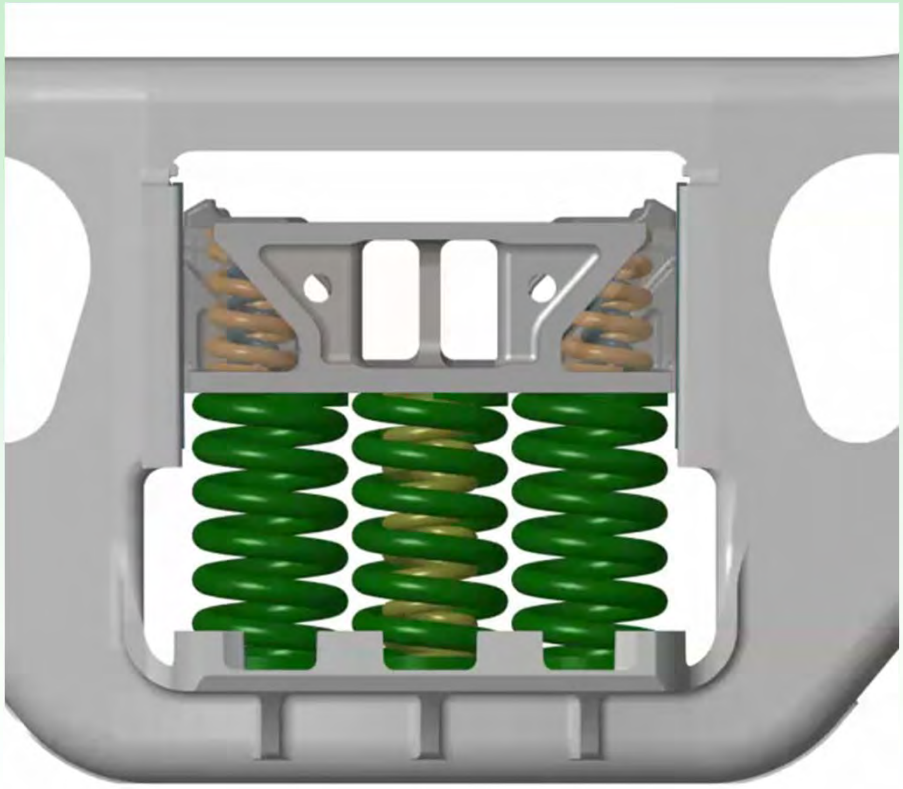
Secondary Truck Suspensions

** Friction Damping ~ F x D

Variable damping



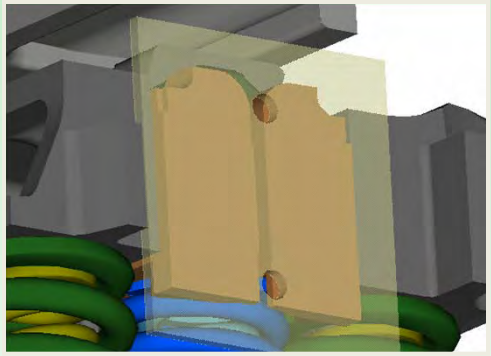
Constant damping

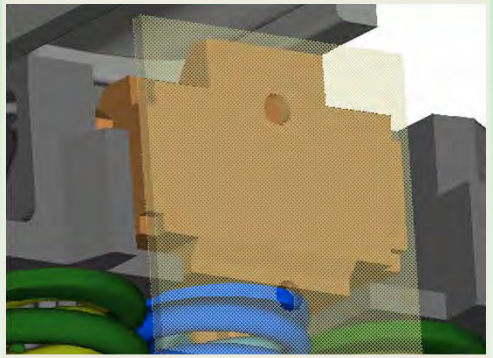


Damping Advantages

Constant Damping:

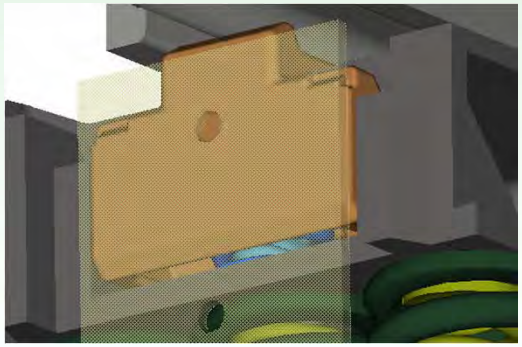
- Long Service Life
- Moderate Track Ride
- Light Car Truck Warp





Variable Damping:

- High C. of G. Approval
- Ease of Maintenance
- Rough Track Ride
- Service Life Varies by Design



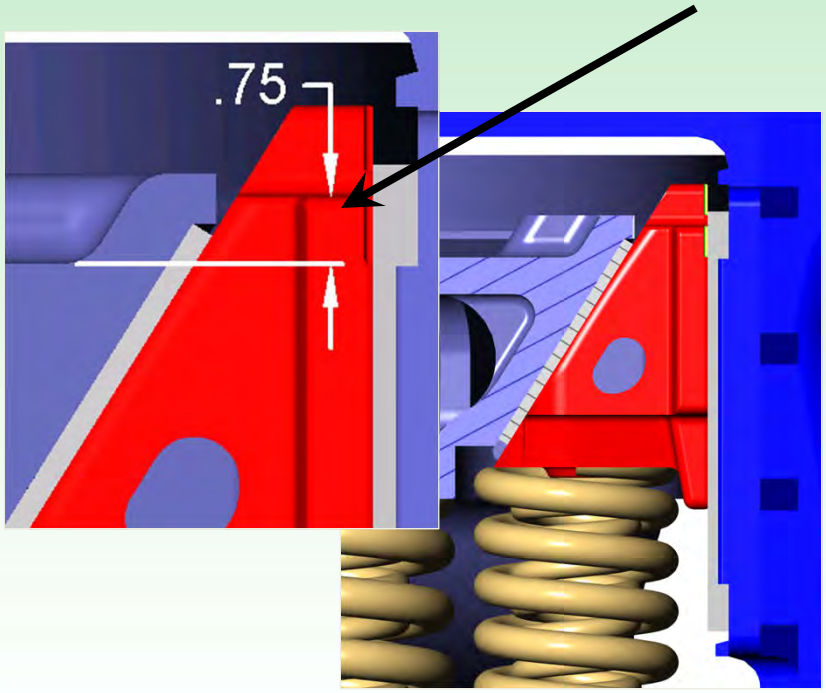
Hydraulic Damping in suspensions?

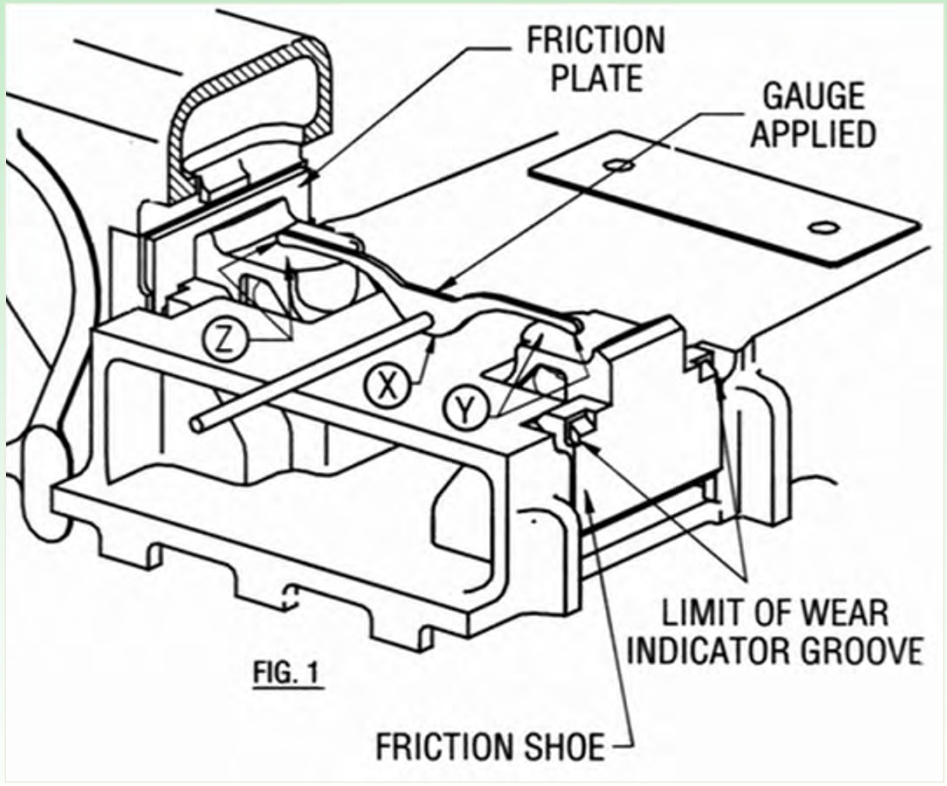
Hydraulic damping:

- Good Performance
- High Speed
- Service Life?
- Maintenance

Truck Maintenance

Most wedges have
built-in wear indicators



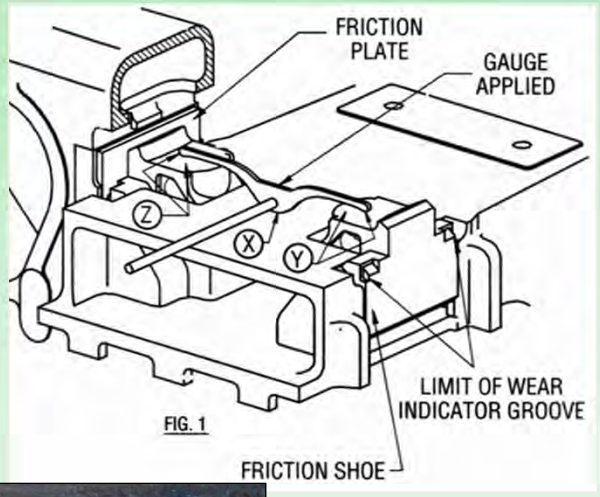


CCSB must be “long travel”

Use these

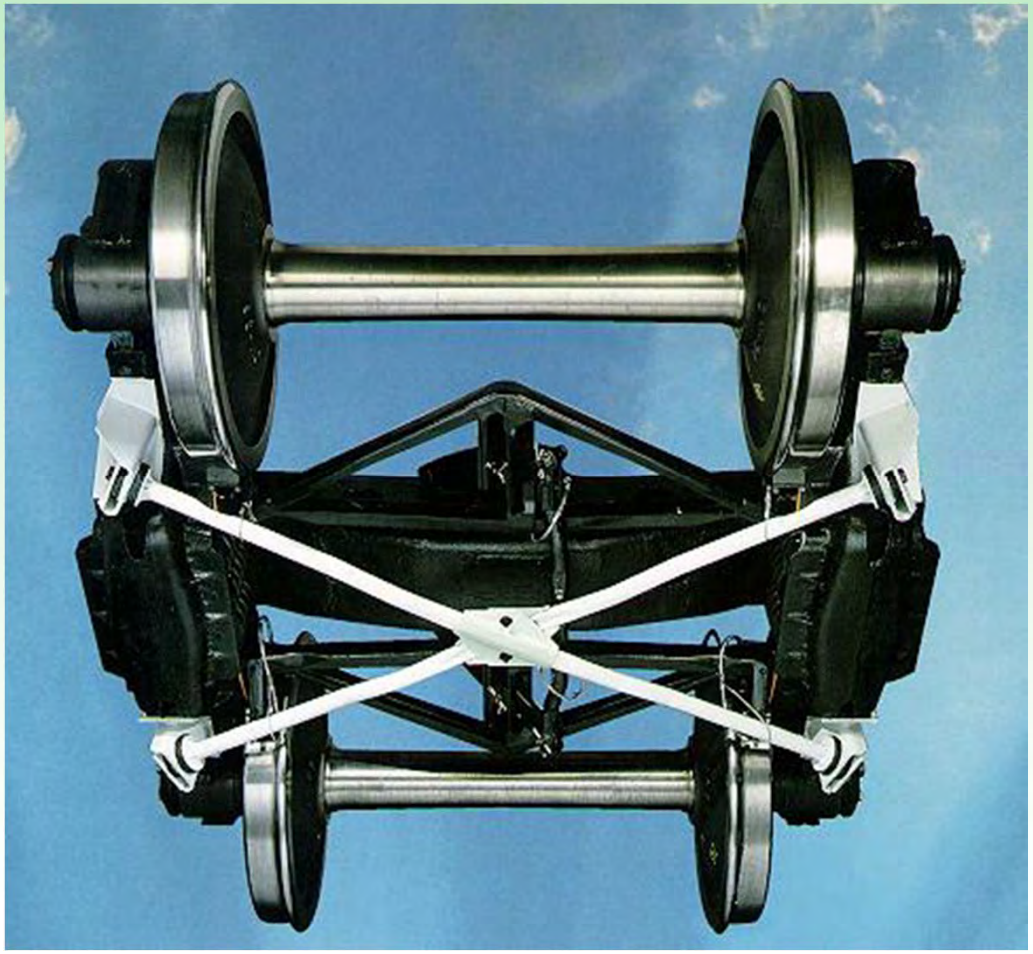
Truck Inspection

- Shoe Rise
- Column Wear Plate Bolts
- Gibs
- Springs

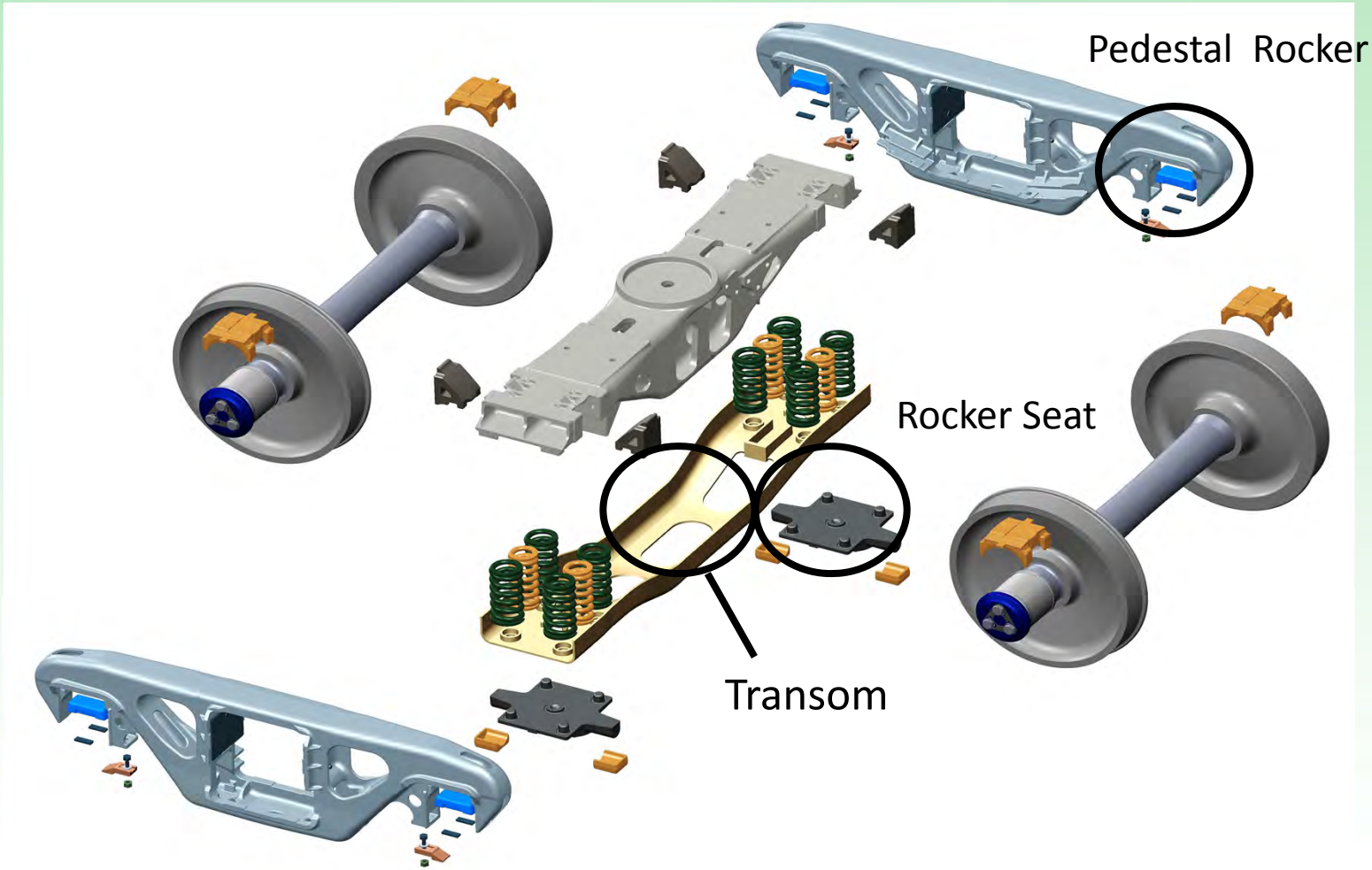


Frame Braced truck

- Increases warp stiffness
- Typically added to a 3-piece truck



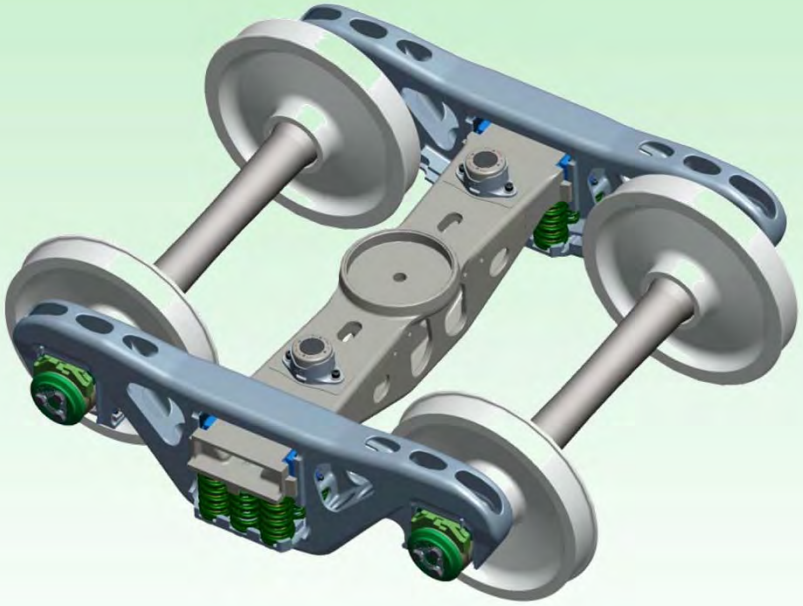
Swing Motion® truck



Summary

- Trucks operate as part of an overall system
- Utilize primary and secondary suspensions
- Dynamic performance is dependent on the assembled suspension parts
- Good maintenance is critical to continued performance and overall life of the system

Thank You - Questions



AmstedRail