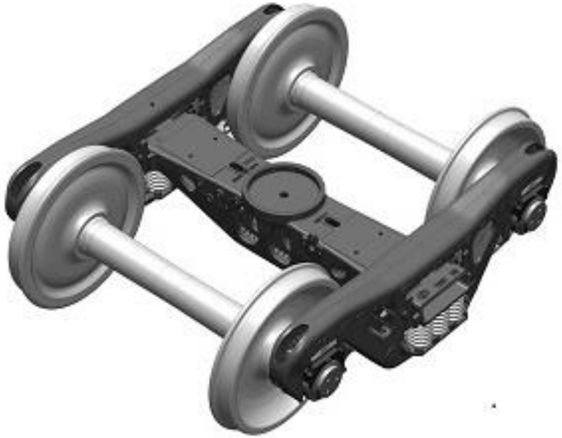
Evolution of Expectations for 3-Piece Trucks



Topics

- Trucks:
  - Performance Expectations (not design or maint.)
- **Wheel/Rail Interface**:
  - Fundamental to railroading yet poorly understood
- History:
  - Last 25 years…

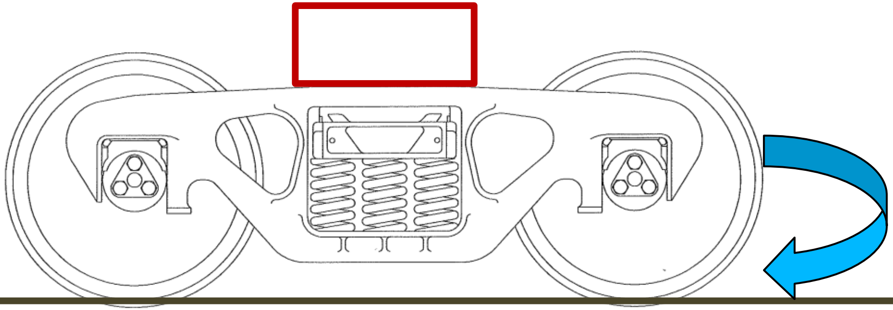
Basic Expectations for the Truck:

- Always start with the "Don'ts"
  - Don't break (Foundry practice & Maintenance)
  - **Don't derail**
  - **Don't wear rapidly**
- Safety, reliability and low cost are critical
- Fundamentals never change

The Truck

Car Body:
Mass & Inertial Forces

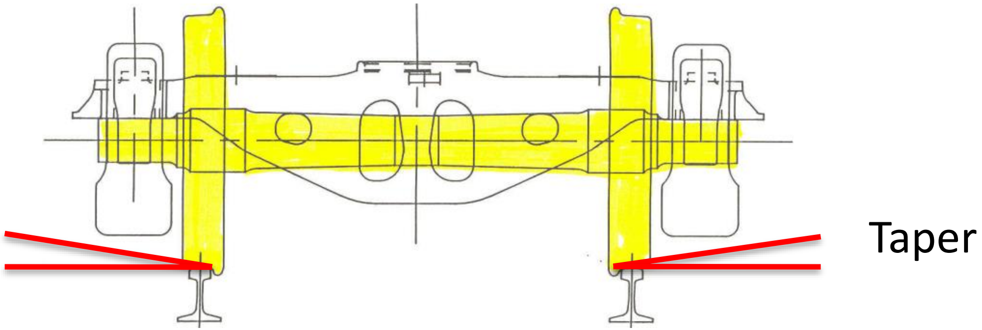
Coupler
Force

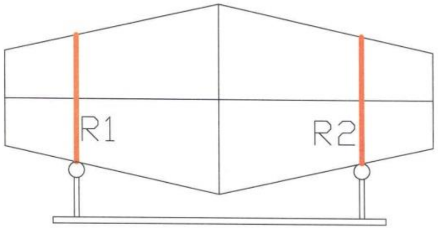


Steering & Hunting
Forces from Wheelsets

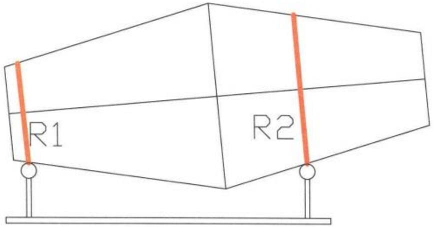
WRI:
Wheelsets use RRD to hunt for the track.
(Only the wheelsets know where the track is, it is their job to guide the truck.)

Rolling Radius Difference

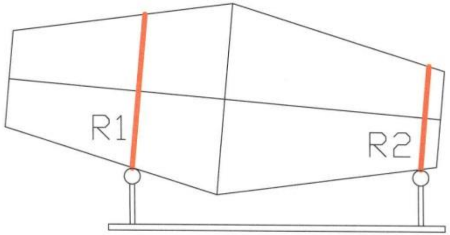




Tangent



Left Curve



Right Curve

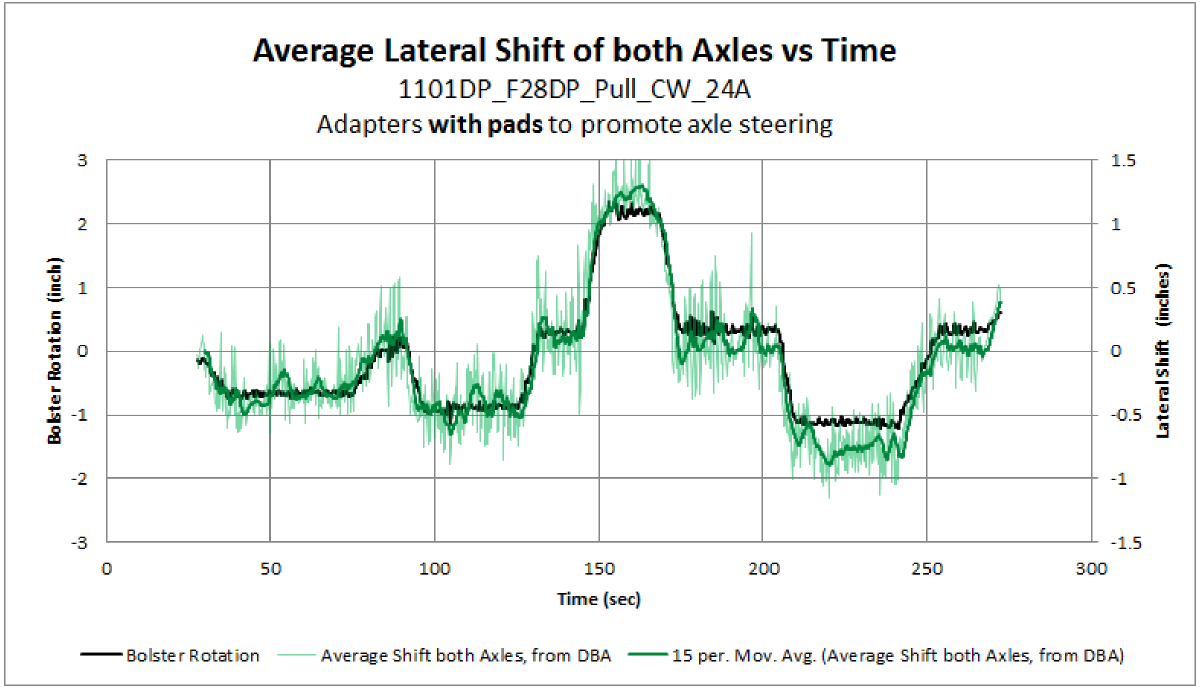
Wheelset on 12 degree curve

High Rail

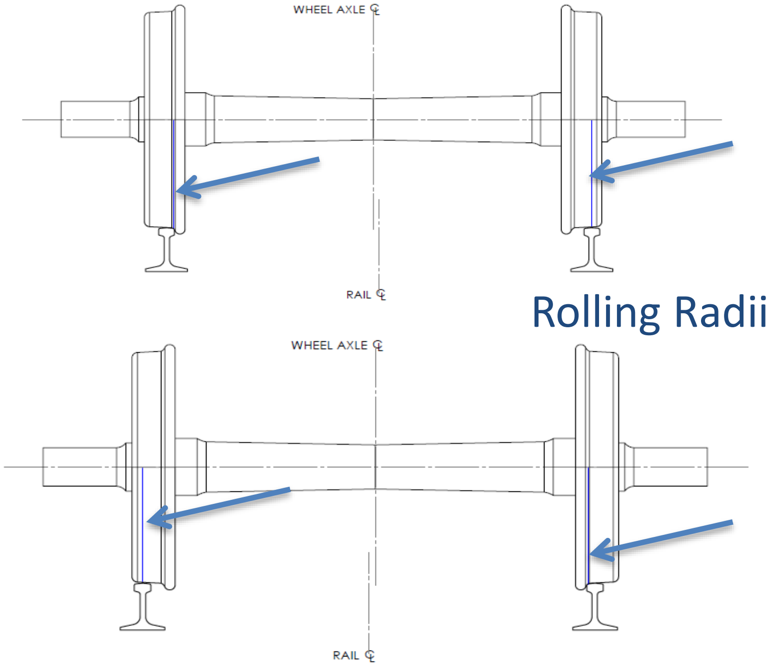
Low Rail

Wheelset RRD

Wants to follow the track

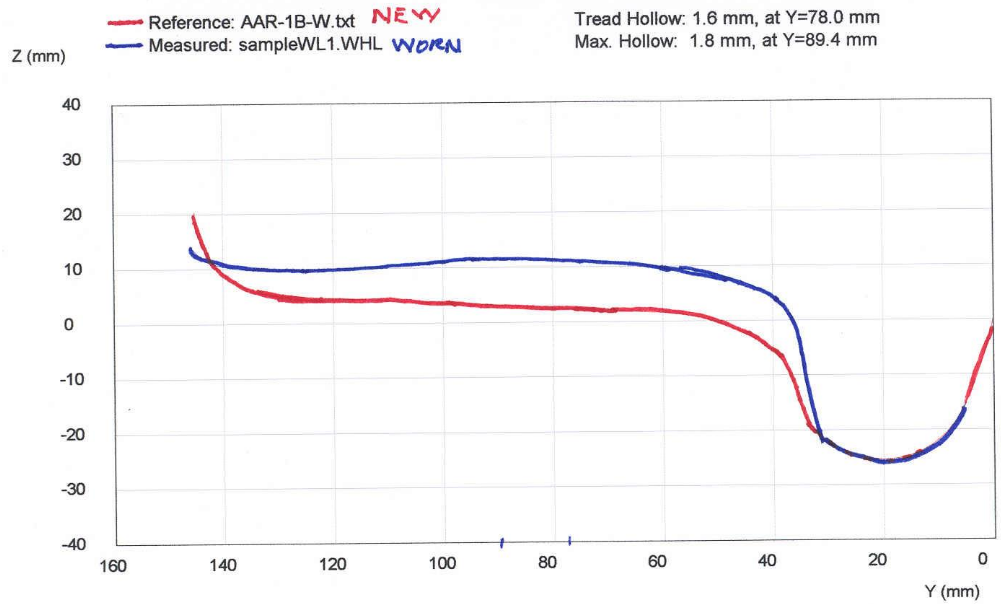


Calculating RRD

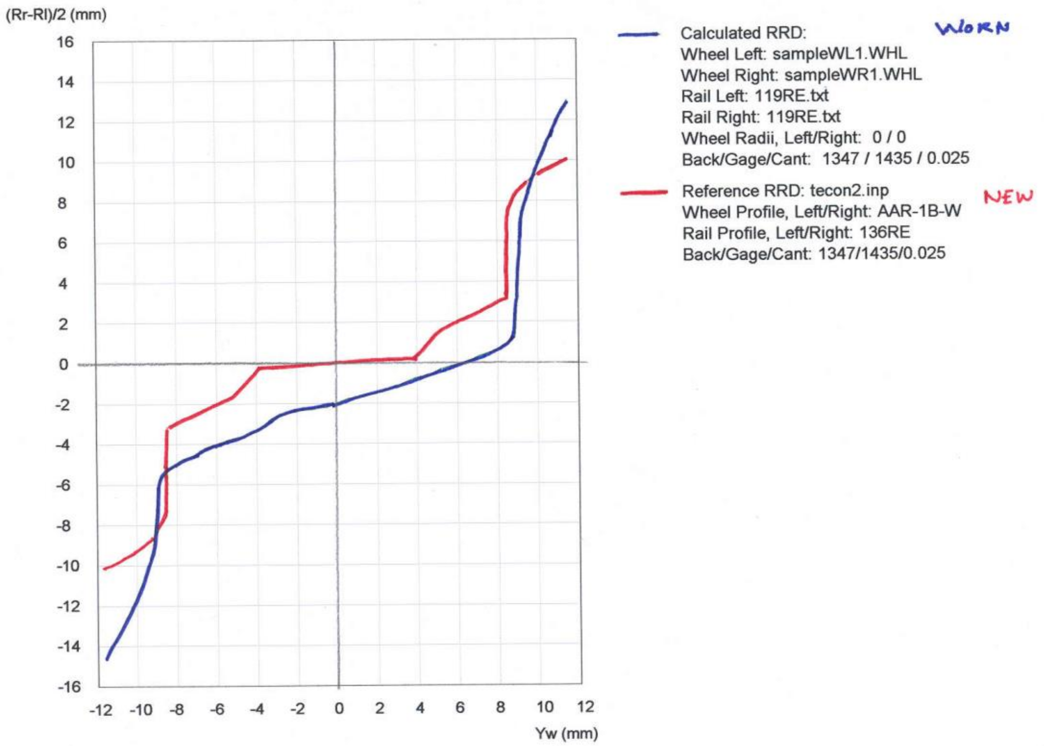


We can measure the wheel diameters and profiles, and rail profiles and use software to calculate the RRD as the wheelset contact points are moved laterally across the rails.

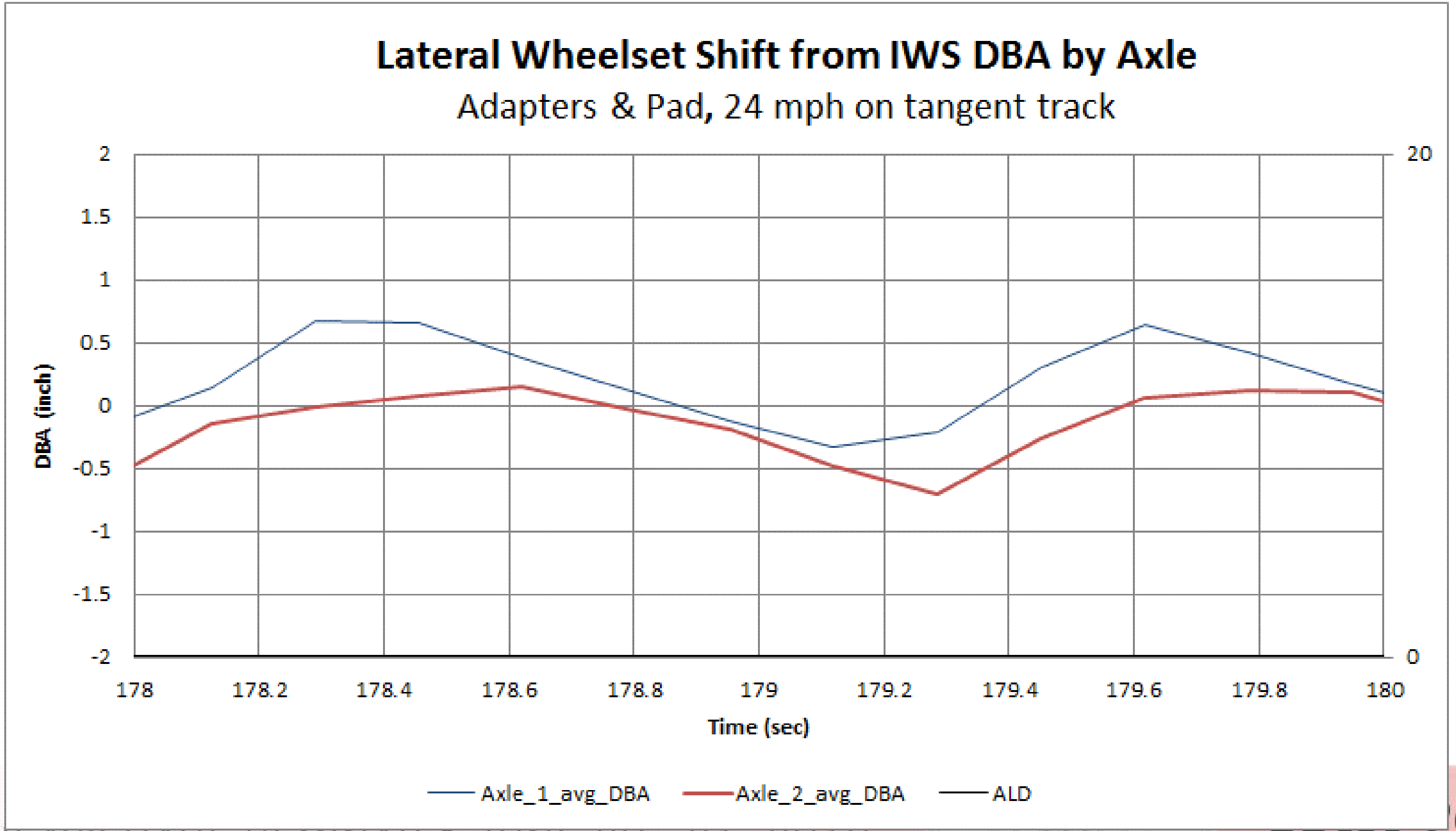
New & Worn Profiles



RRD Plot


(Rr-Rl)/2 (mm)
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
Yw (mm)
Calculated RRD:
WORN
Wheel Left: sampleWL1.WHL
Wheel Right: sampleWR1.WHL
Rail Left: 119RE.txt
Rail Right: 119RE.txt
Wheel Radii, Left/Right: 0 / 0
Back/Gage/Cant: 1347 / 1435 / 0.025
Reference RRD: tecon2.inp
NEW
Wheel Profile, Left/Right: AAR-1B-W
Rail Profile, Left/Right: 136RE
Back/Gage/Cant: 1347/1435/0.025

RRD gives a wavelength



Lateral Wheelset Frequency vs. Speed

Wavelength Cycle in ft	Speed (mph)	ft-Sec/Mile-hour Conversion	Wheelset Lateral Input Frequency (Hz)
46	30	1.46667	0.96
46	40	1.46667	1.28
46	50	1.46667	1.59
46	60	1.46667	1.91
46	70	1.46667	**2.23**

Frequency Response

2–12 BASIC VIBRATION THEORY

The acceleration response is obtained by differentiating Eq. (2.36):

$$\frac{\ddot{x}}{F_0/m} = -\frac{\omega^2}{\omega_n^2} R_d \sin(\omega t - \theta) = -R_a \sin(\omega t - \theta) \qquad (2.37)$$

The velocity and acceleration response factors defined by Eqs. (2.36) and (2.37) are shown graphically in Fig. 2.13, the former to the horizontal coordinates and the latter to the coordinates having a negative 45° slope. Note that the velocity response factor approaches zero as $\omega \rightarrow 0$ and $\omega \rightarrow \infty$, whereas the acceleration response factor approaches 0 as $\omega \rightarrow 0$ and approaches unity as $\omega \rightarrow \infty$.

At Resonance: Huge Gain

Low Frequency Input = Output

High Frequency Attenuation

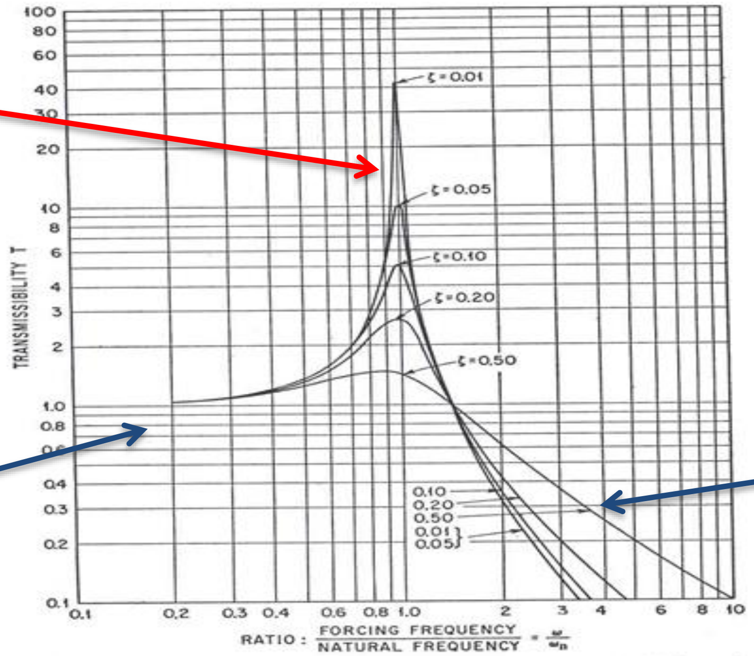
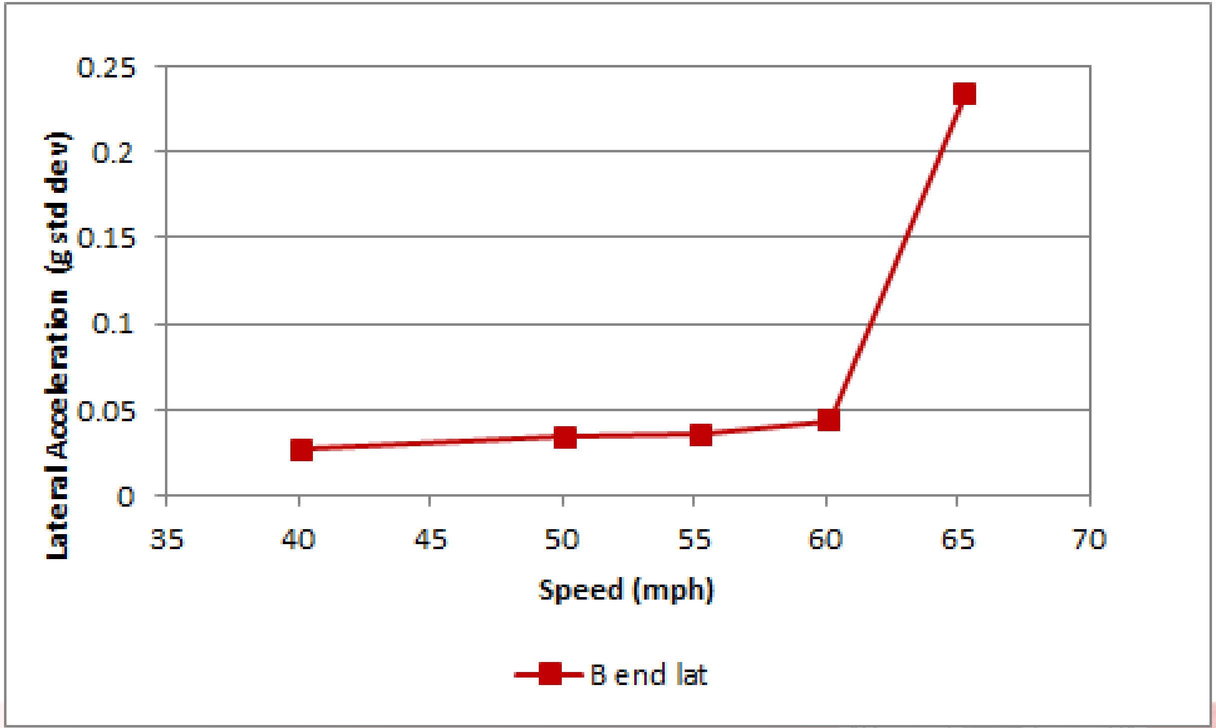
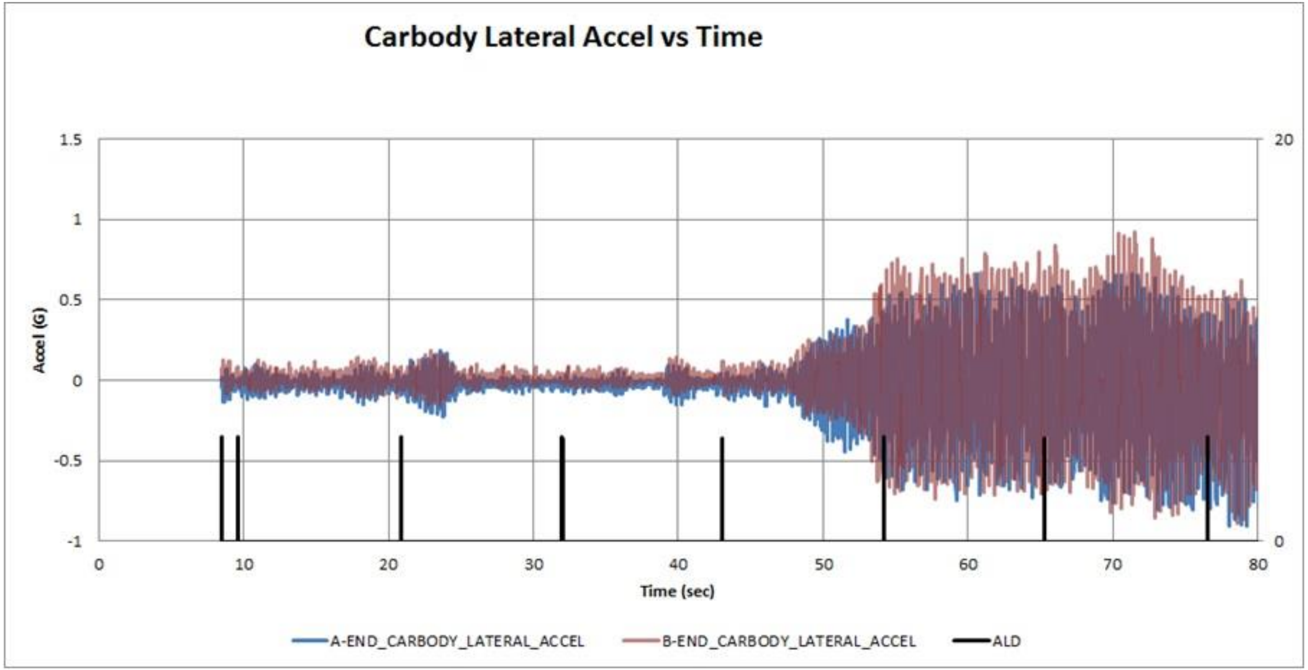


Fig. 2.17. Transmissibility of a viscous-damped system. Force transmissibility and motion transmissibility are identical numerically. The fraction of critical damping is denoted by ζ.

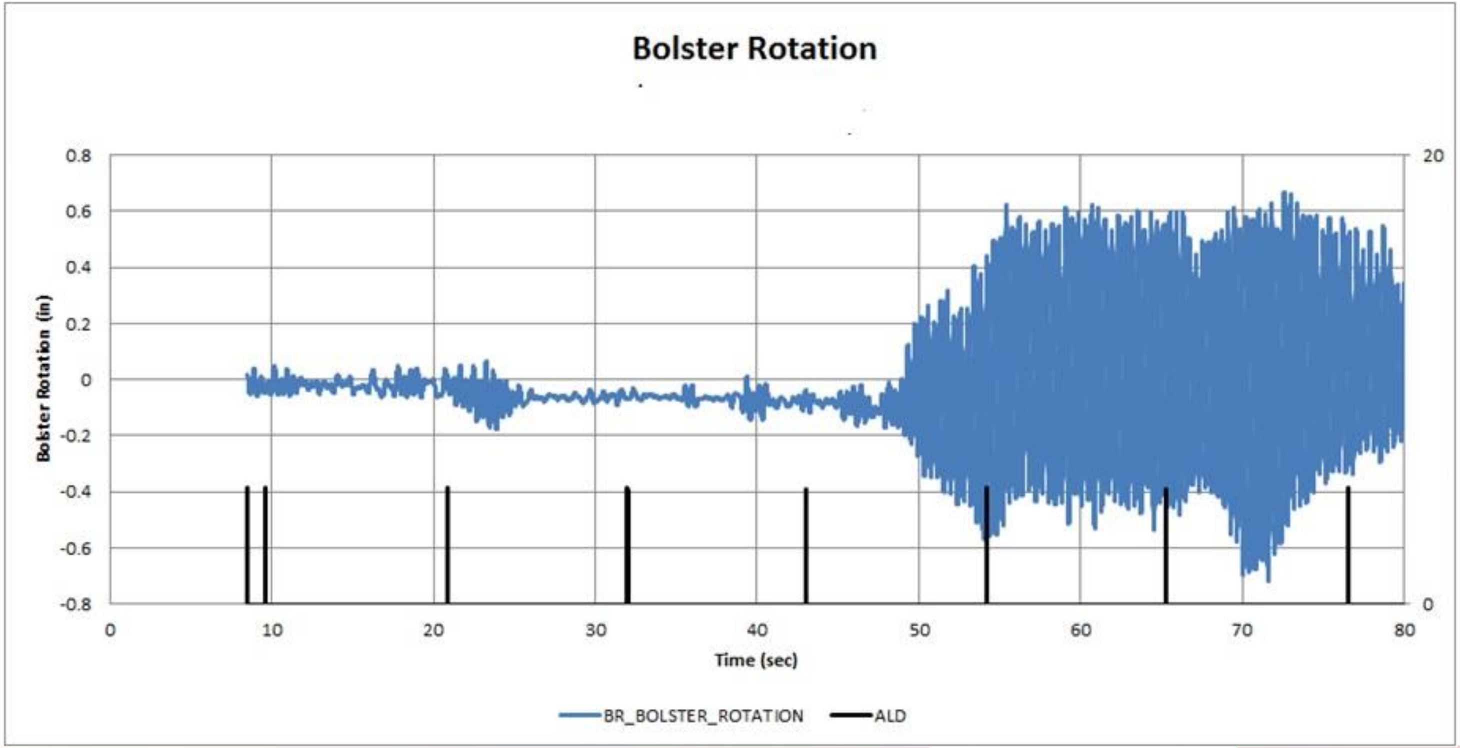
High Speed Stability Track Test
Lateral car accelerations, g std dev



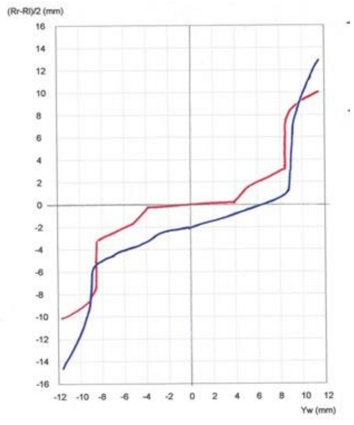
Lateral Deck Accelerations, 60 mph

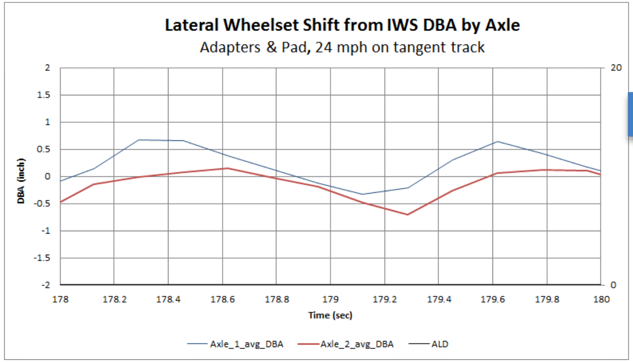


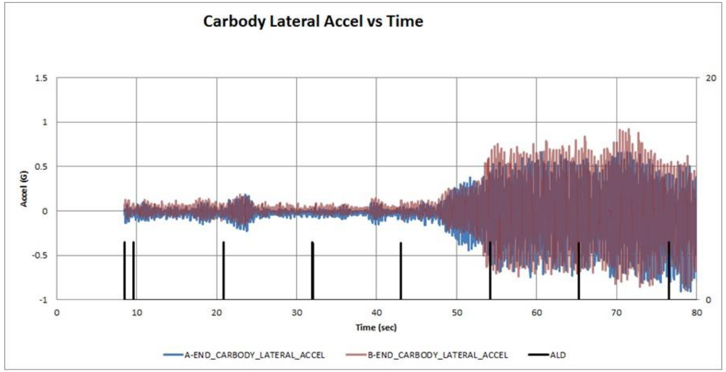
Truck Bolster Rotation, (inch) 60 mph

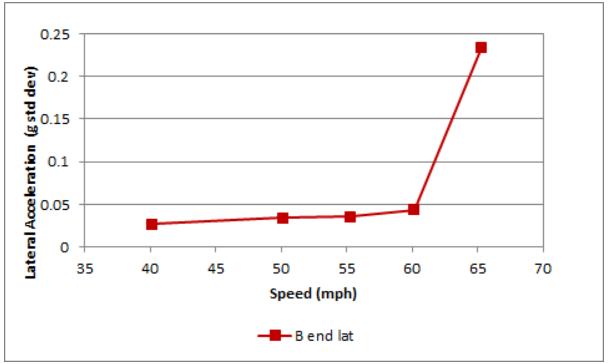


Review


(Rr-Rl)/2 (mm)
Yw (mm)


Lateral Wheelset Shift from IWS DBA by Axle
Adapters & Pad, 24 mph on tangent track
DBA (inch)
Time (sec)
Axle_1_avg_DBA
Axle_2_avg_DBA
ALD


Carbody Lateral Accel vs Time
Accel (G)
Time (sec)
A-END_CARBODY_LATERAL_ACCEL
B-END_CARBODY_LATERAL_ACCEL
ALD


Lateral Acceleration (g std dev)
Speed (mph)
B end lat

High Speed Stability

- 25 Years Ago:
  - AAR: 0.26 G Std. Dev. at 70 mph (damage)
  - New Wheelsets (low conicity, little hunting)
  - New car condition
  - Empty car only

High Speed Stability

- Today:
  - AAR: 0.13 G Std. Dev. at 70 mph (onset of hunting)
  - Worn Wheel Profile (higher conicity, more hunting)
  - Empty and loaded car
  - New car condition and…
  - THD sites monitoring cars in service
  - Main driver for million-mile truck castings

25 Years Ago

Truck Performance	AAR: Wheel L/V < 1, 10% min vert. wheel load (New car)
Truck Life	600K miles
Wheel Life	Blame the brake system
Stress State/Rail & Fuel Savings	N/A
Find poor performing trucks	Derailed in curves

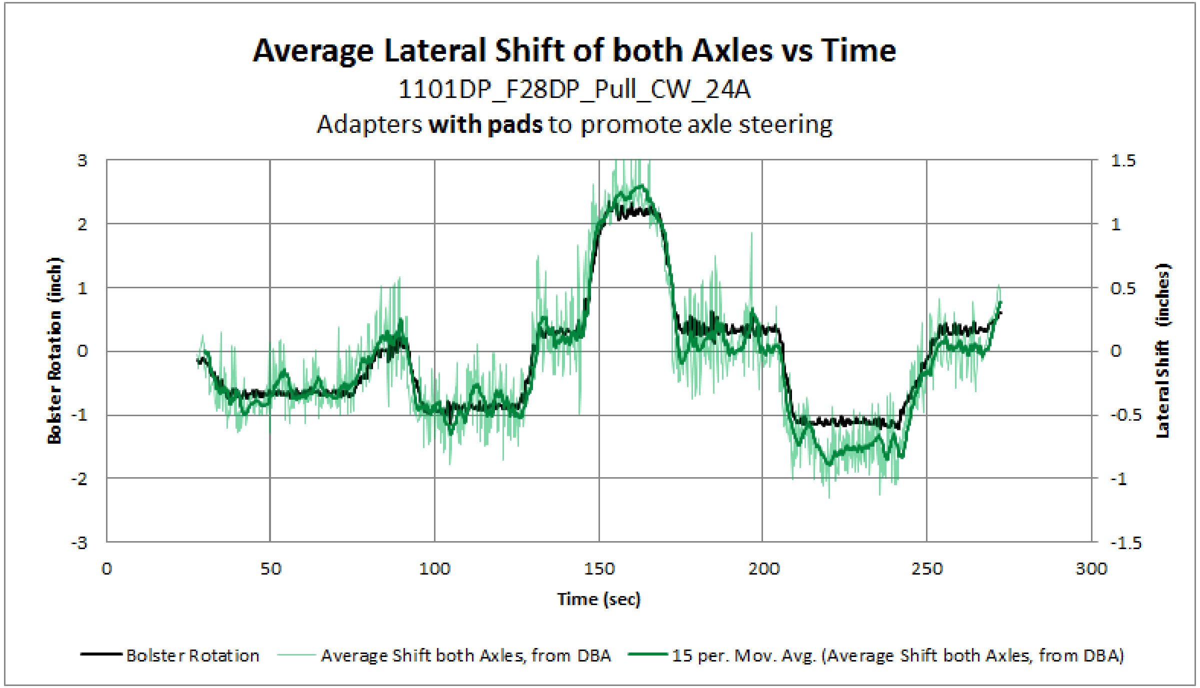
Today

Truck Performance	AAR & M-976 & Wayside Detectors (New & in service)
Truck Life	Over 1 Million miles
Wheel Life	RCF, WILD, CEPM, TC brake shoes
Stress State/Rail & Fuel Savings	M-976, Cooperative efforts to remove bad actors. Use wayside data for condition based maintenance. More data driven.
Find poor performing trucks	Detector alerts & data trending

The Future of Truck Expectations

- Evolve from the Don’ts to the Do’s
  - The truck design should do its job:
    - The Truck can’t make the wheelset perform better than its RRD and WRI can perform
    - The truck system’s job is to support the car body with sufficient damping and stability at speed, while letting the wheelsets take the correct trajectory for the track curvature, based on the wheelset/rail RRD parameters.

Did this truck do its job?
Did wheelset trajectory match the track?



The Future of Truck Testing

- Science is good for making discoveries. Those discoveries still need to be engineered into technically sound test procedures.
- Tests should be engineered to reveal the measurement of interest with a high signal-to-noise ratio. Small numbers, close to zero, inherently have a poor signal-to-noise ratio.
- A well engineered test also keeps the value and accuracy of the test in balance with the cost and precision of the DUT.
- Track testing is good for verifying function of the whole system but it introduces many uncontrolled variables.

The Future of WRI

- The interface of wheelsets and track are very important to railroading
- Today, car owners own the wheels, RRs own the track.
- This creates a natural tension for interchange rules on wheels

The Future of WRI

- What if the owners of the track were also joint owners of the wheels and jointly responsible for WRI?
- Owners of the wheels and tracks would decide among themselves when to change wheels and what profiles to use, reducing tension.
- The rail industry is already good at sharing assets and oversight, it could work…