Wheel Rail Interface Studies from a Light Rail Alignment with Two Types of Vehicle Fleet

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- **Jeff Curran, Andrew Wistrand, Anthony Nguyen** – Siemens Mobility

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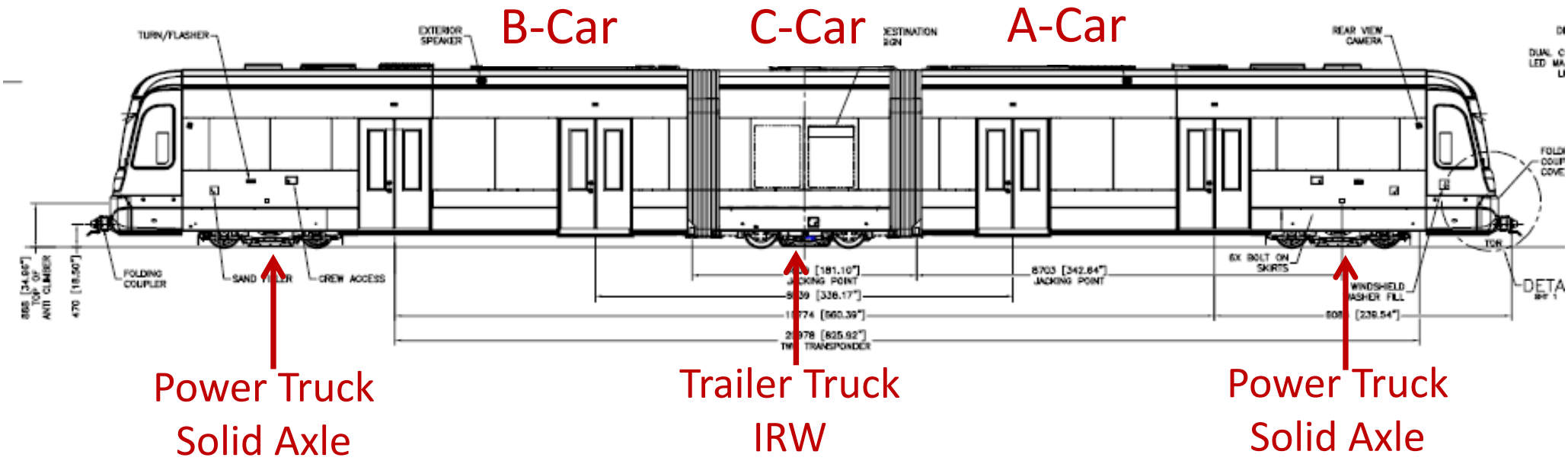
Sound Transit's Link Light Rail Fleet

Series 1 LRVs – Kinkisharyo
Entered Rev Service – 2009
Total in Service – 62 LRVs

Series 2 LRVs – Siemens
Entered Rev Service – 2021
Total in Service – 49 LRVs
Total by 2025 – 152 LRVs

LRVs – 70% Low Floor Vehicles

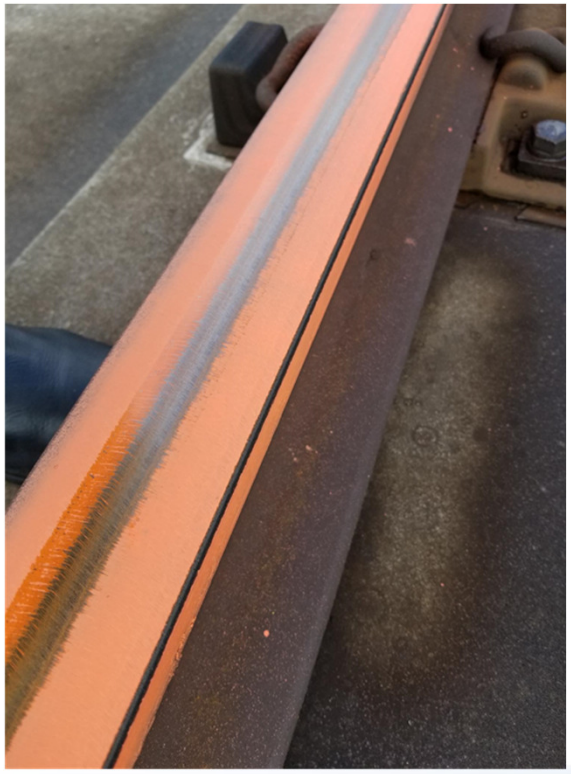


Key Motivation for this Work

1. **Multiple contact bands on the rail, especially at curves**
2. **Understand uneven wheel wear/behavior**
3. **Wayside train noise and vibration control**

Example of Multiple Contact Bands

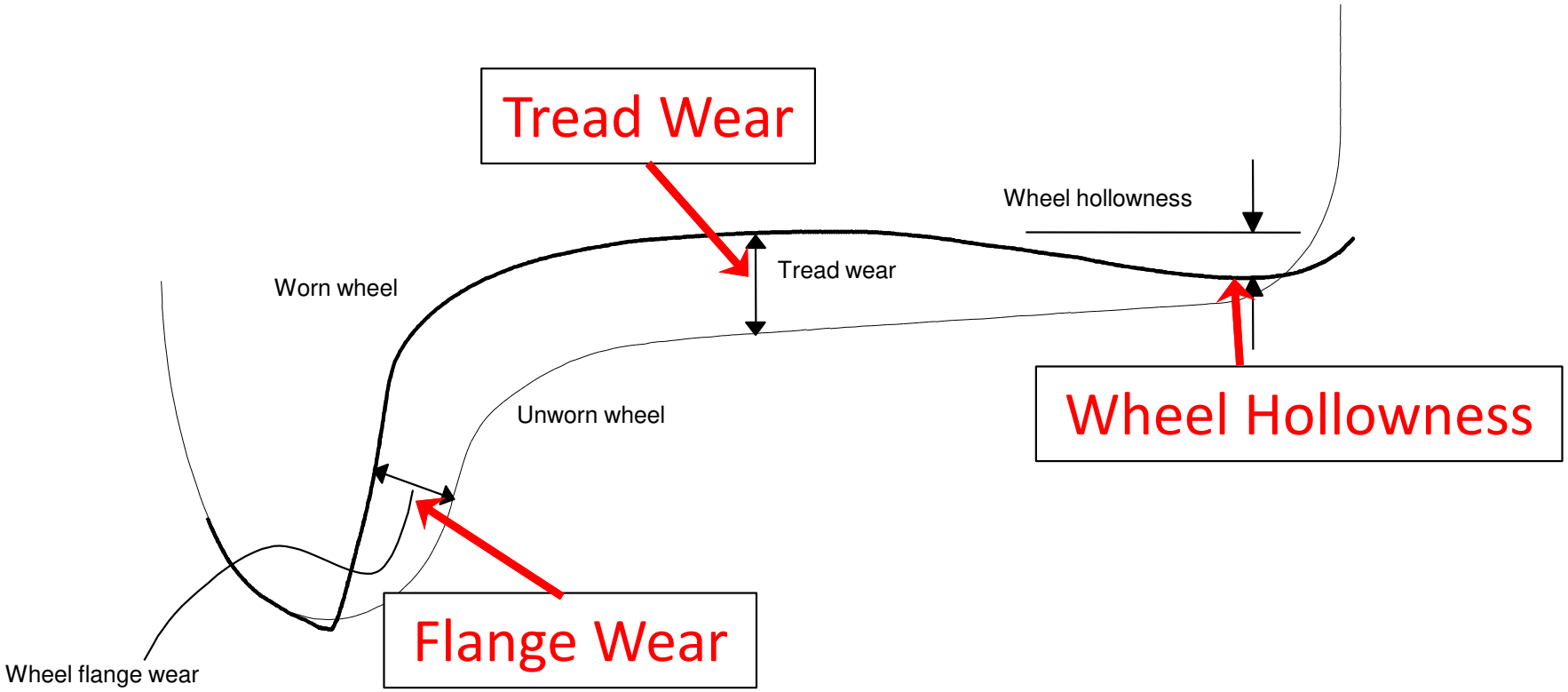
2 – Contact bands



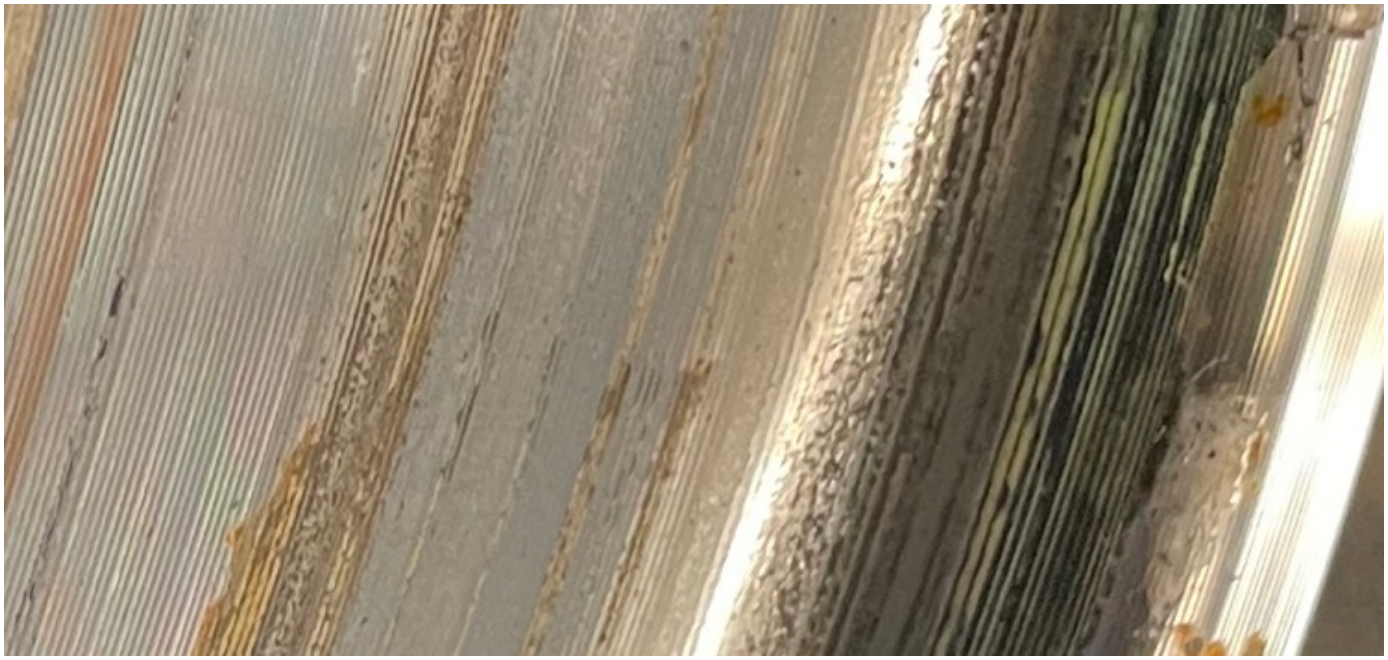
3 – Contact bands

4 – Contact bands

Key Wheel Wear Issues



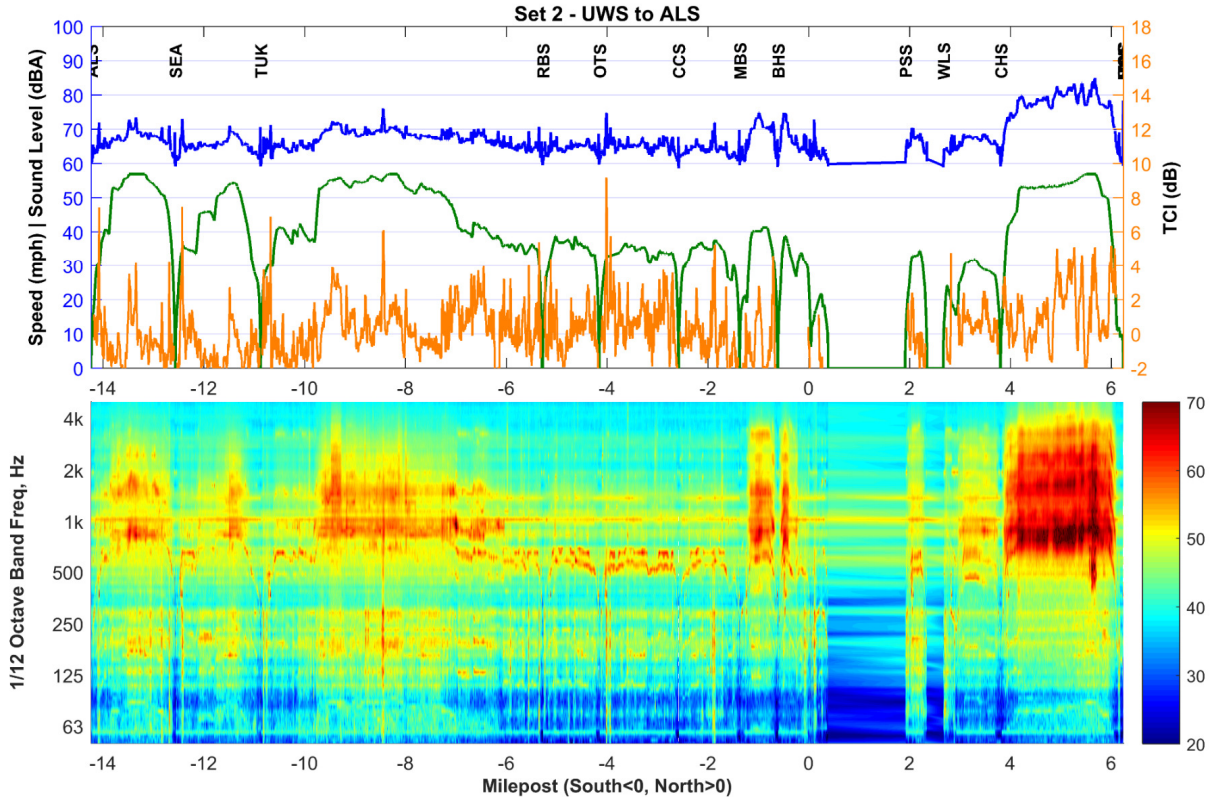
Wheel Surface and Truing

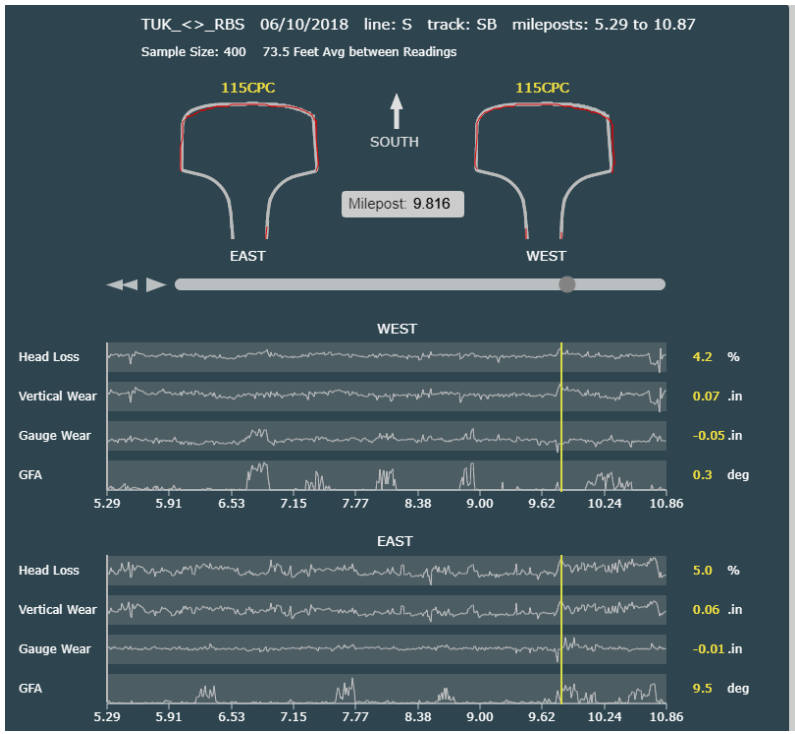


Performance Metrics – Focus Areas

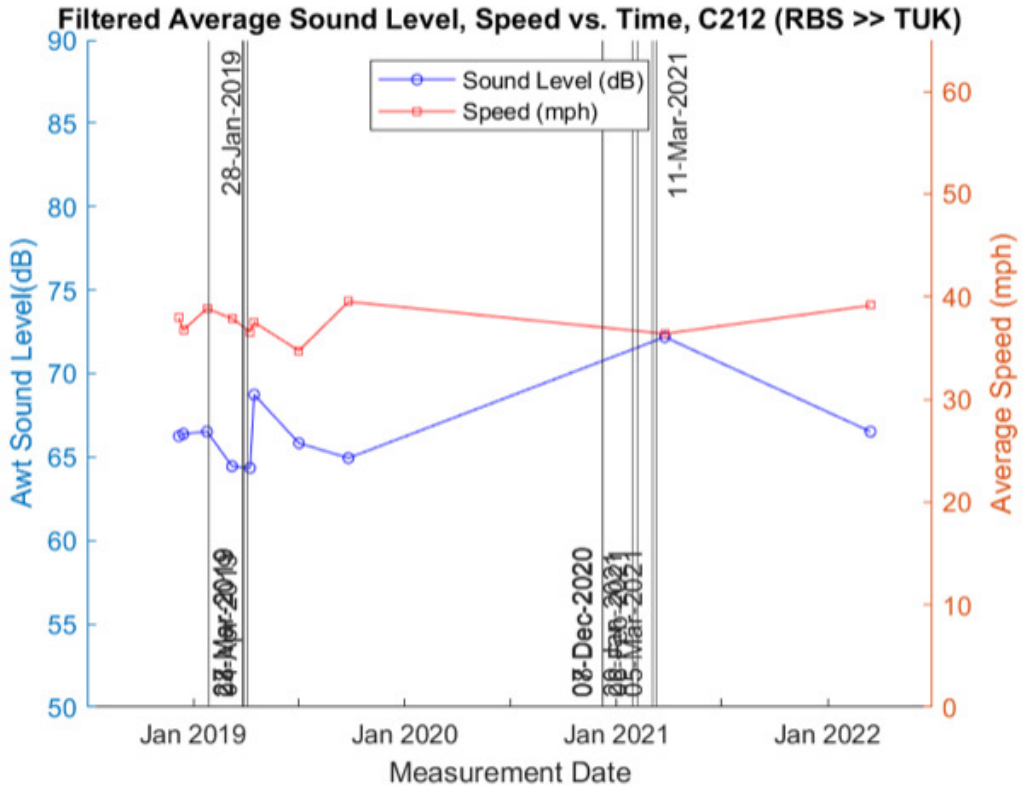
1. Safety (#1 Priority)
2. Maintenance (Wheel and rail surface conditions)
3. Environmental (Wayside noise and vibration)
4. Passenger comfort (Truck dynamics, Ride quality)

OnTrack Monitoring & Database



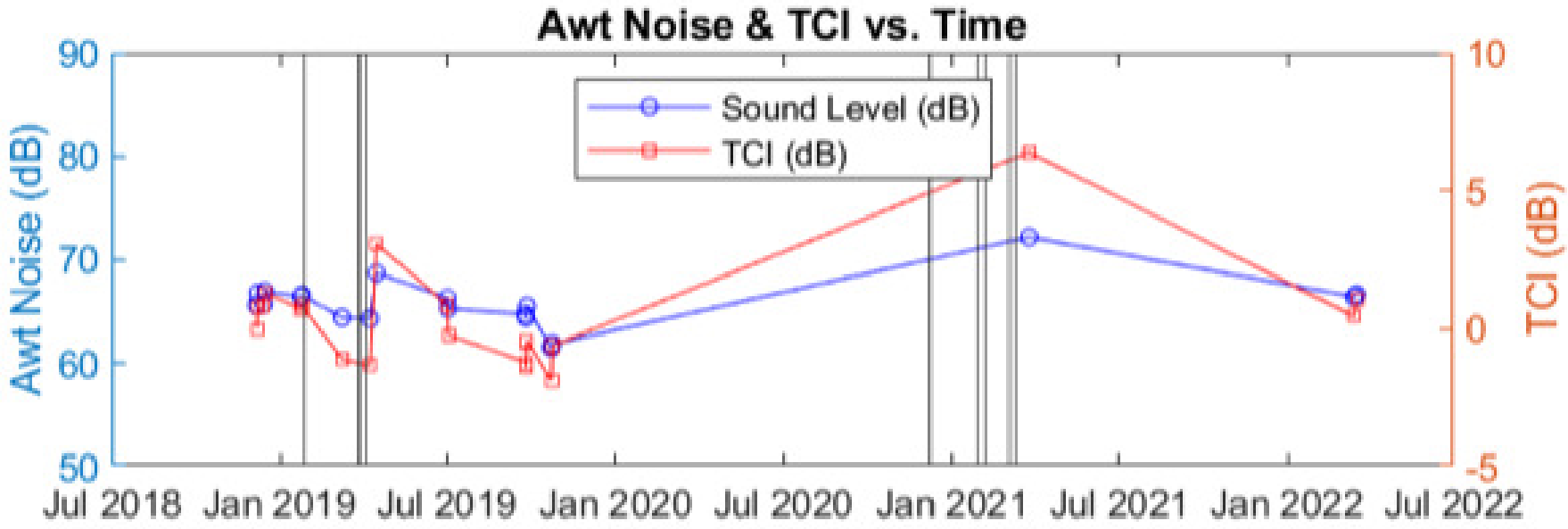


Rail Grinding and Train Noise



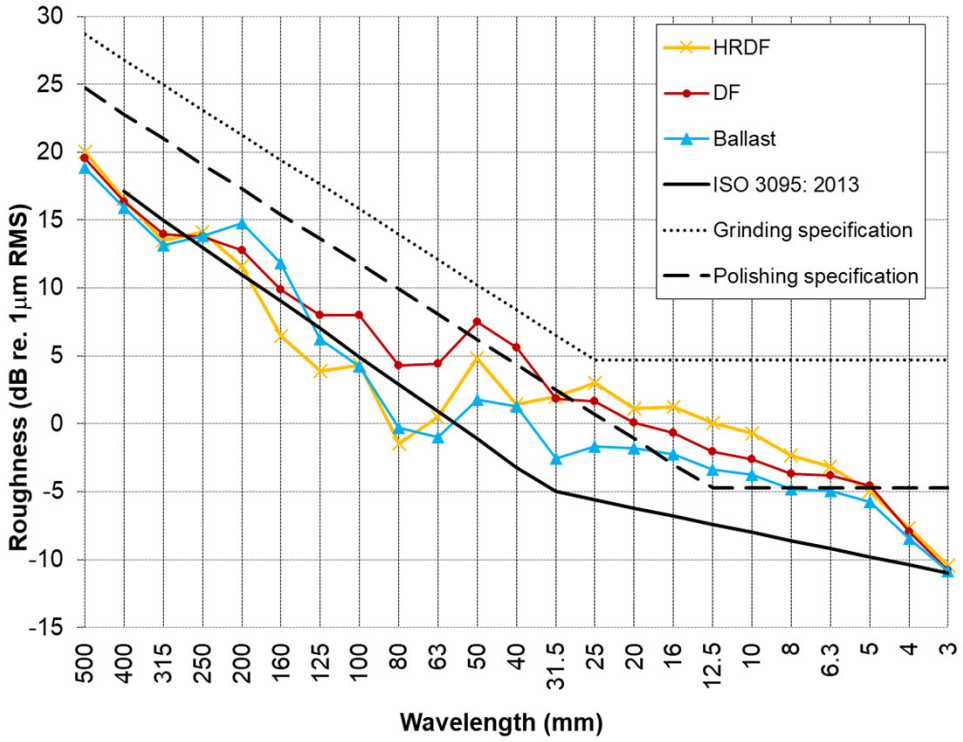
Rail Grinding, TCI & Train Noise

All Awt Sound Level, TCI, Speed vs. Time, C212 (RBS >> TUK)



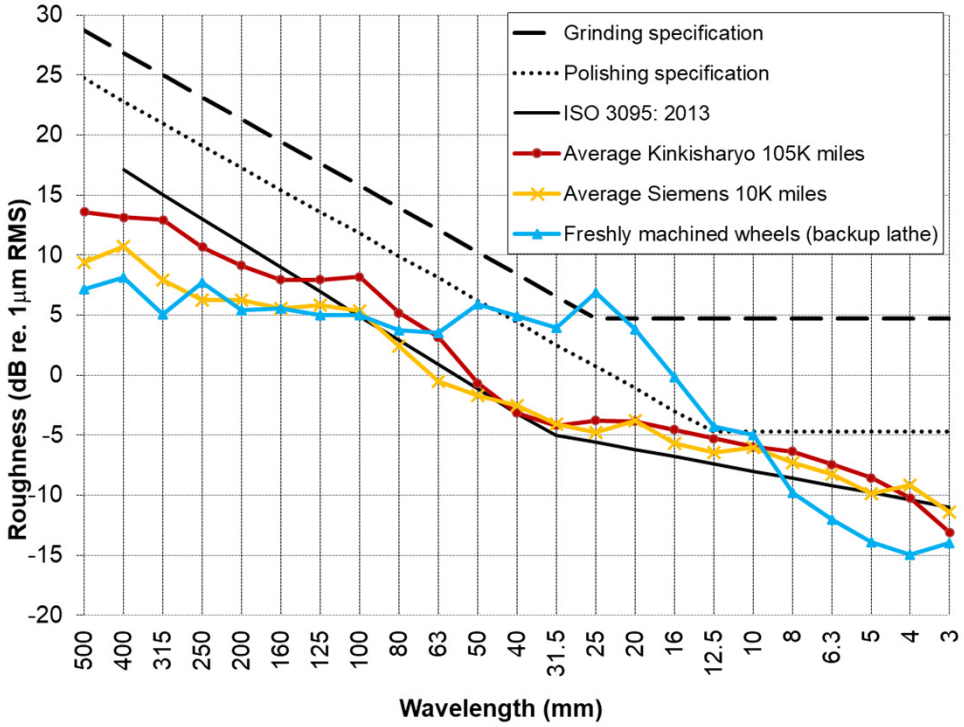
Rail Roughness Measurements

Average Rail Roughness from Track Type



Wheel Roughness Measurement

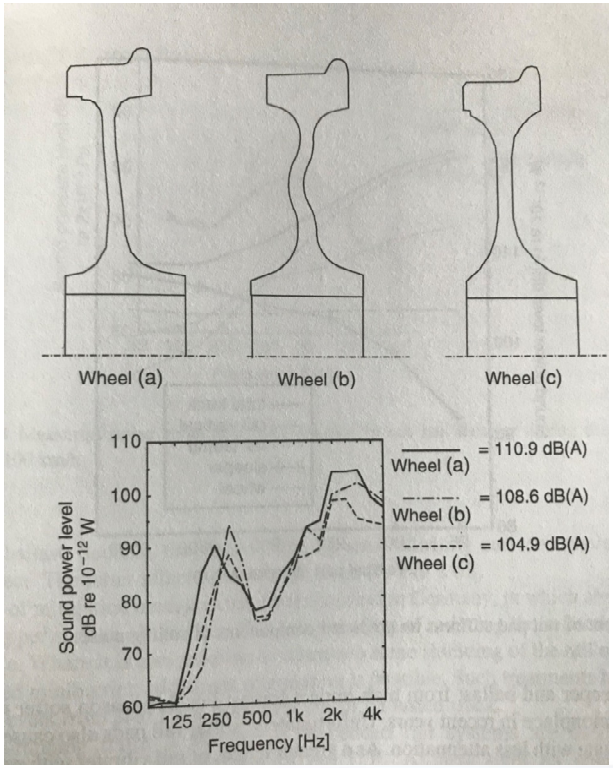
Wheel Roughness from Two Vehicle Types



Preliminary Relative Noise between Car Types

1. Siemens center car wheel is the quietest.
2. The power truck wheels for the two types of LRVs are somewhere in between the center car wheels.
3. KI car center truck is the loudest.

Wheels, Noise & Radiation Efficiency



1. **What are modal frequencies of Bochum 84 and Bochum 2000 wheels?**
2. **How is radiation efficiency influenced by wheel diameter?**
3. **What is the influence of track type on wheel vs rail radiation?**

Wheels, Noise & Radiation Efficiency 26-inch Diameter

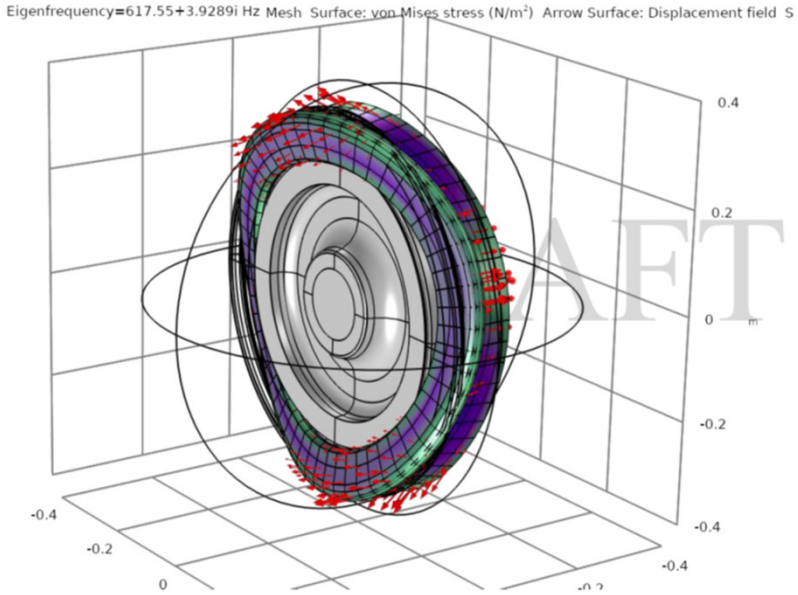


Figure 2 26-Inch Wheel - A-N2 at 617.55Hz

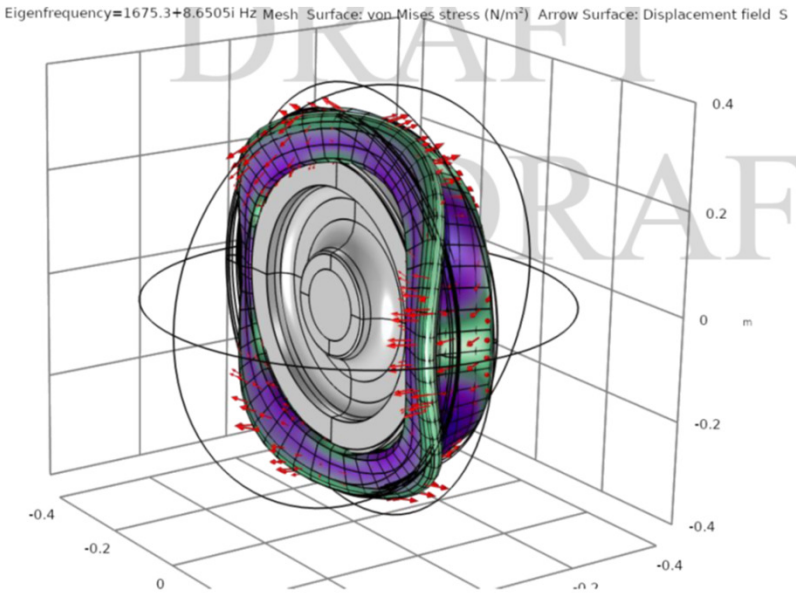


Figure 3 26-Inch Wheel A-N3 at 1675.3Hz

Wheels, Noise & Radiation Efficiency 25-inch Diameter

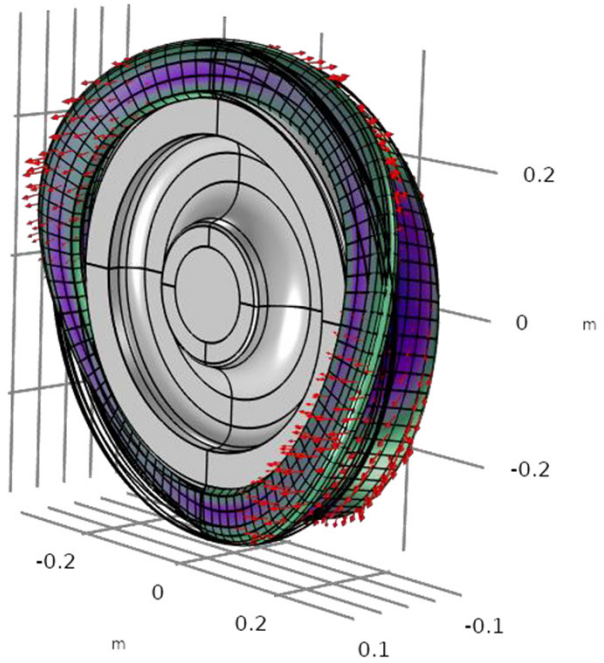


Figure 10 25-Inch Diameter Wheel Axial Mode A-N2 at 577.71Hz

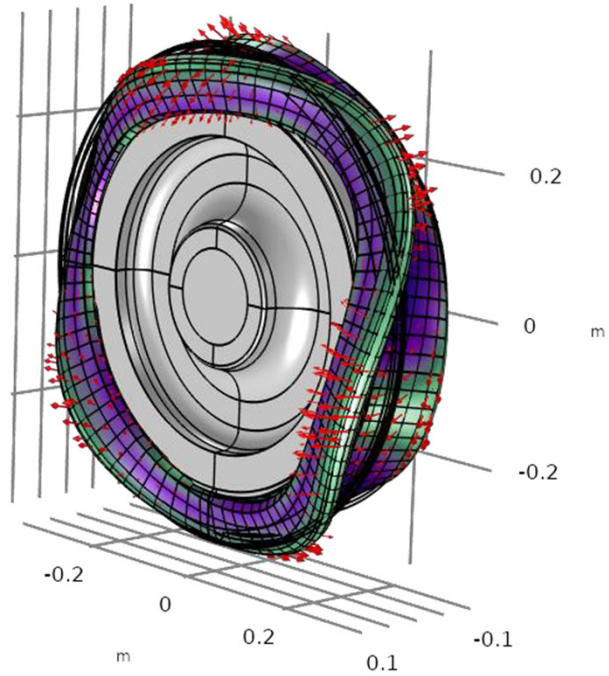


Figure 11 25-Inch Diameter Wheel Axial Mode A-N3 at 1584 Hz

Wheels, Noise & Radiation Efficiency 24-inch Diameter

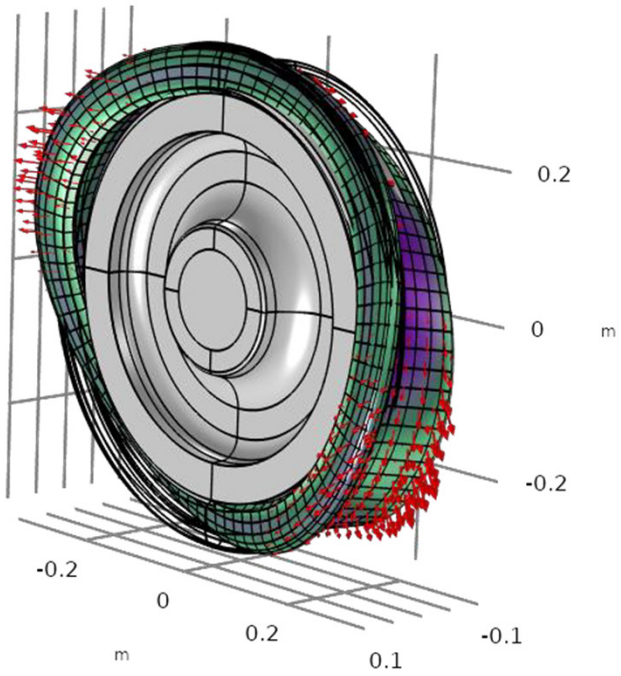


Figure 17 24-Inch Wheel - Axial Mode - A-N2 at 531.43Hz

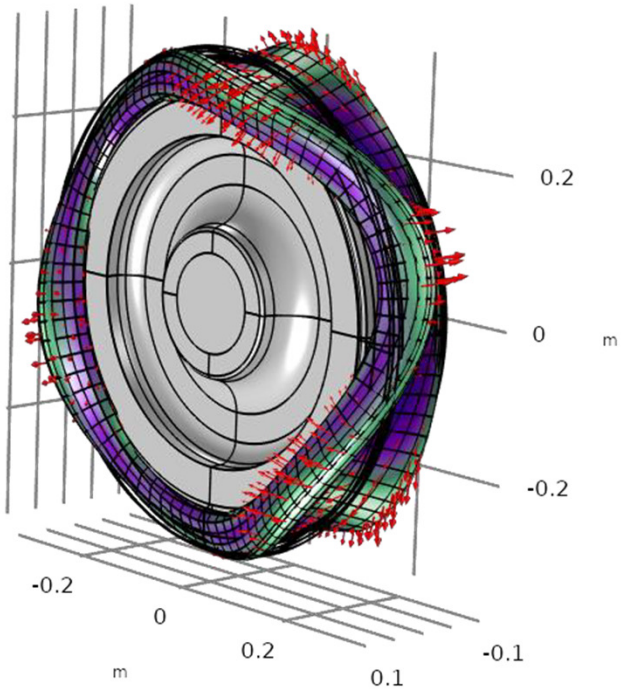


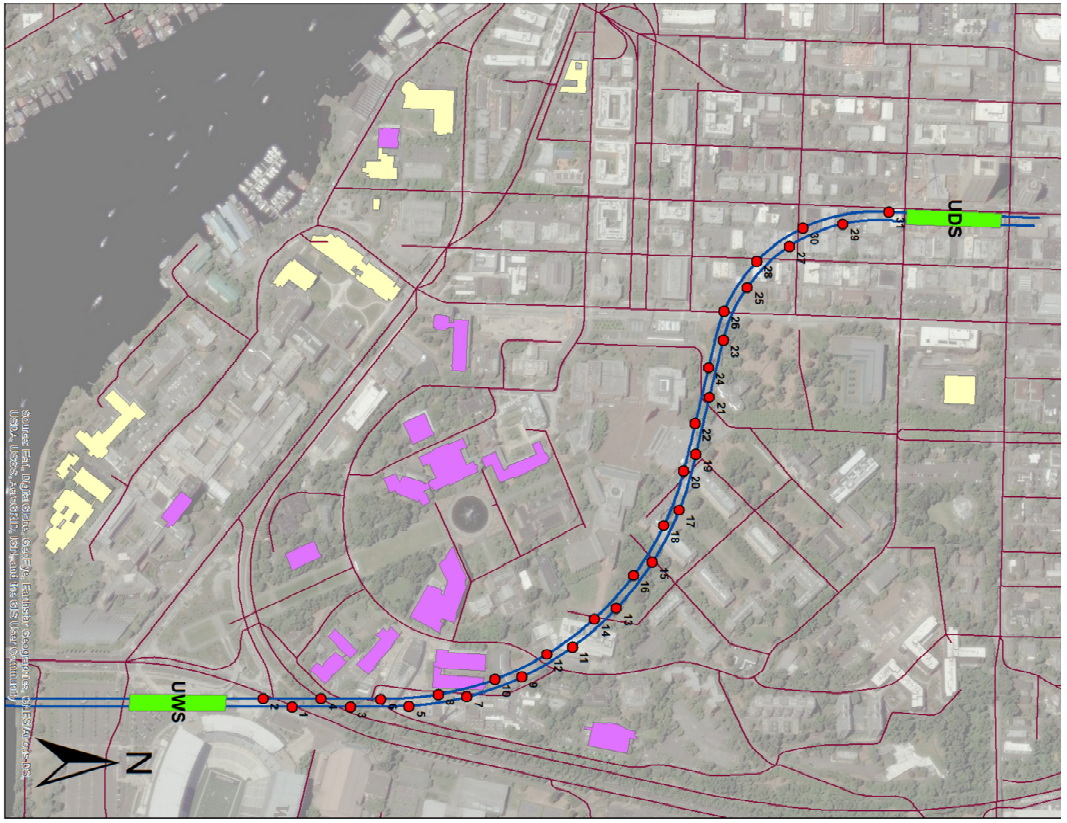
Figure 18 24-Inch Wheel Axial Mode A-N3 at 1425.1Hz

Measured Wheel Wear Summary (2019)

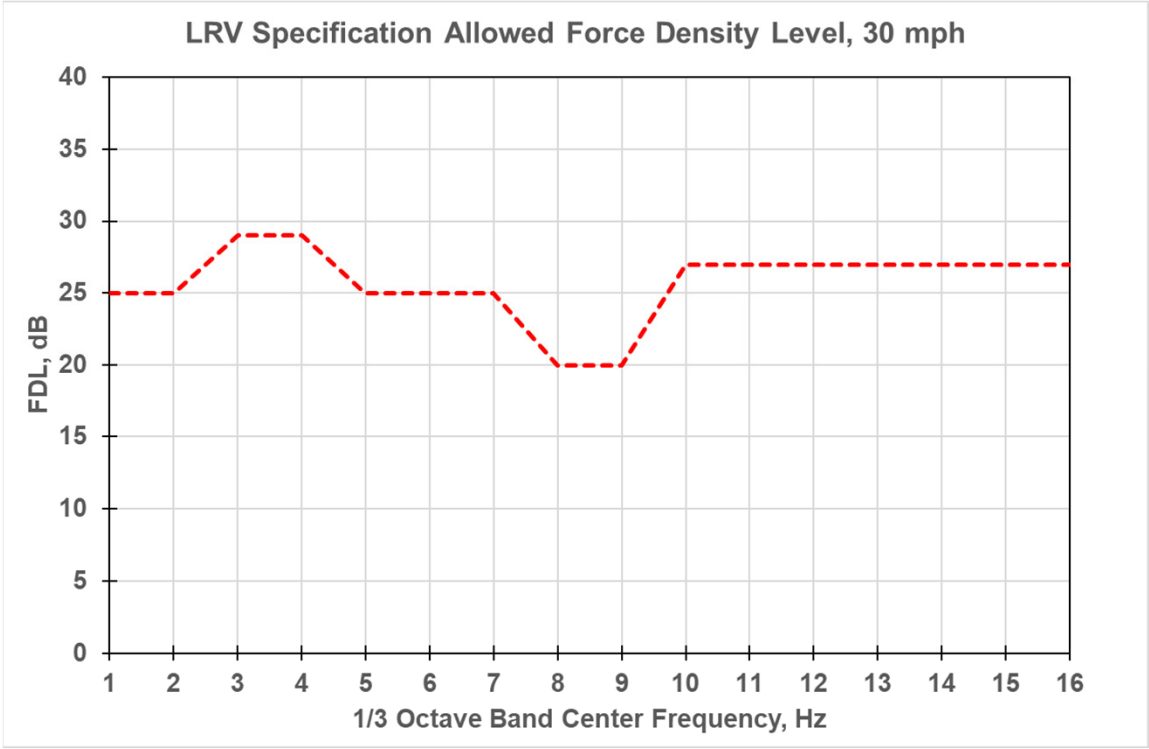
1. Powered truck wheels showed higher hollowness
2. Center truck wheels showed higher flange wear
3. Center truck wheel wear showed some asymmetry

Troubleshooting Example Using Wheel Rail Database

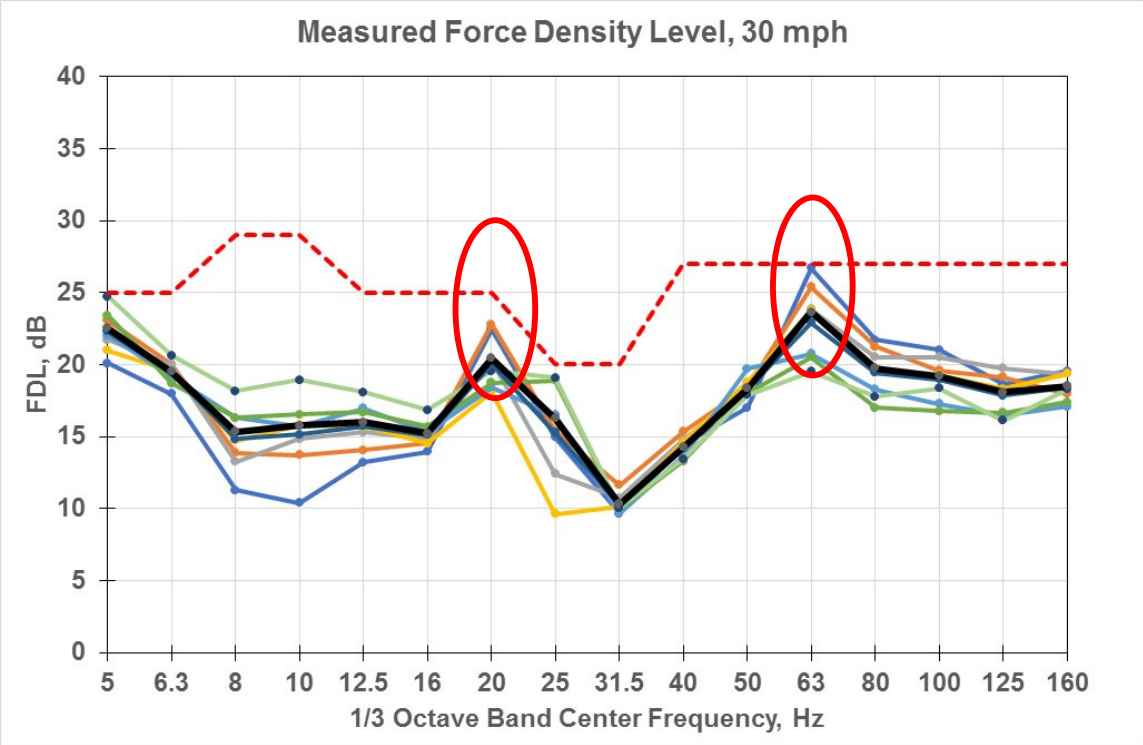
UW Vibration Commitments



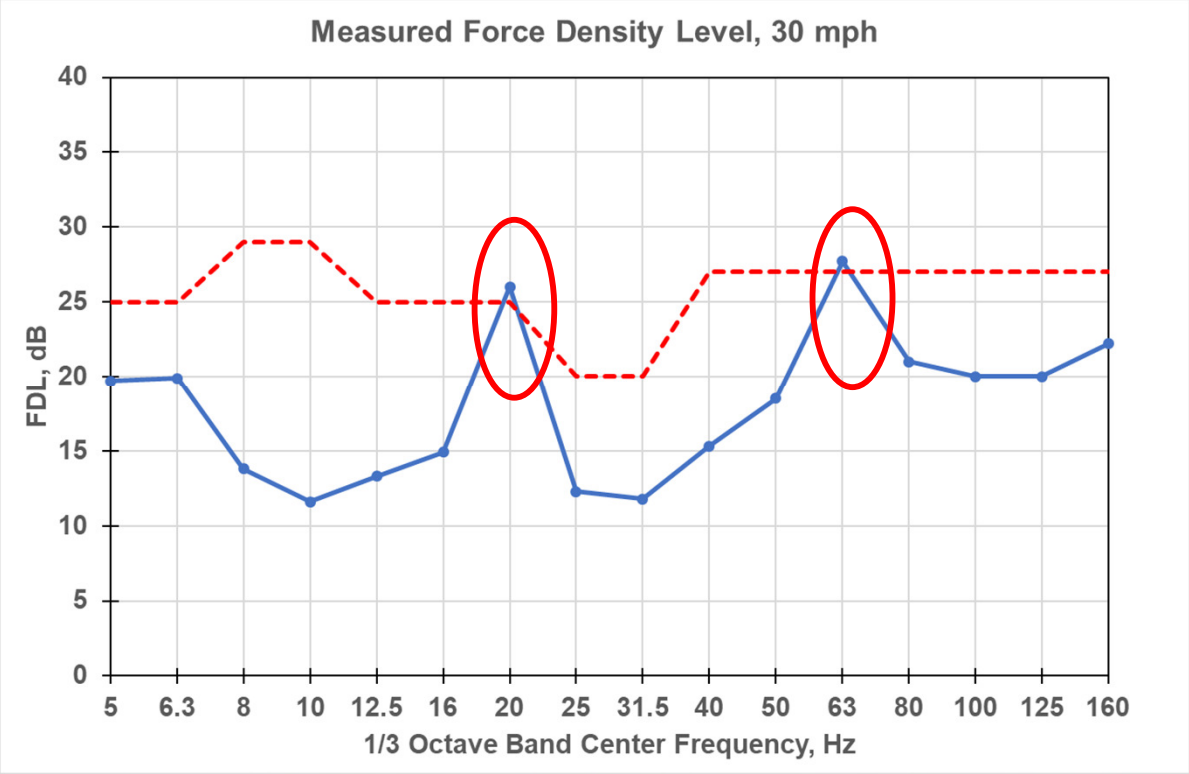
Vibration Requirement for New LRV Acceptance



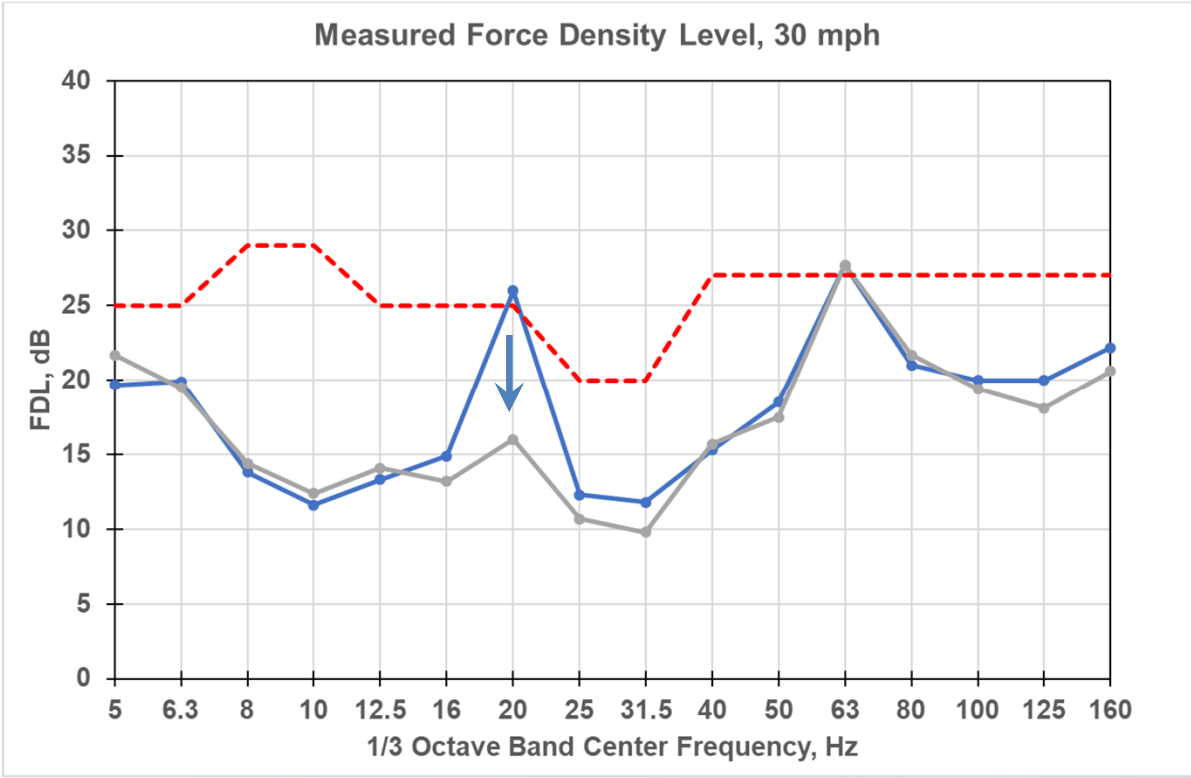
Series 2 LRV Vibration Test Results 2020



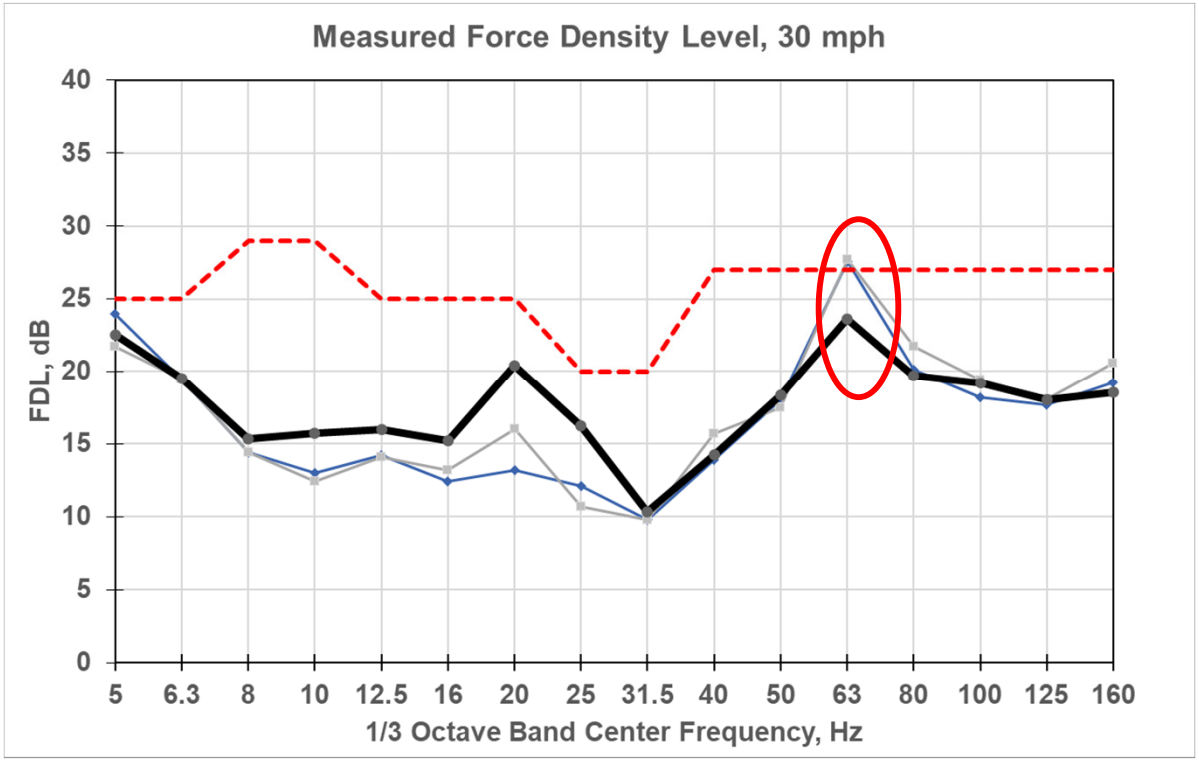
Series 2 LRV Vibration Test Results 2022



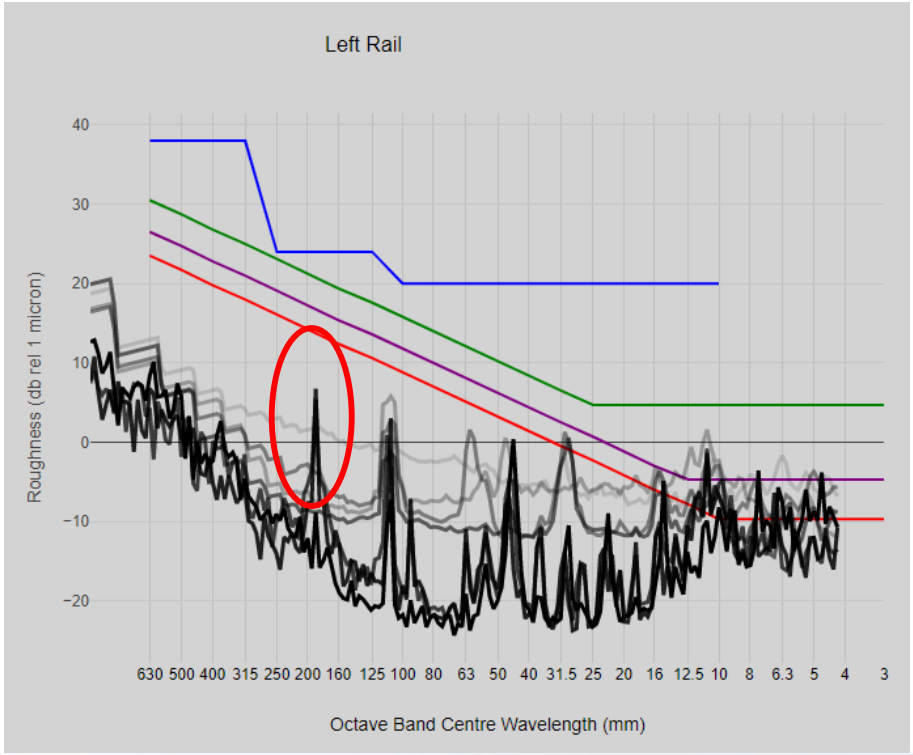
20 Hz Vibration After Truing



63 Hz Vibration Levels – April 2022



Rail Roughness at Test Track Location after 2022 Rail Grinding



Ride Quality

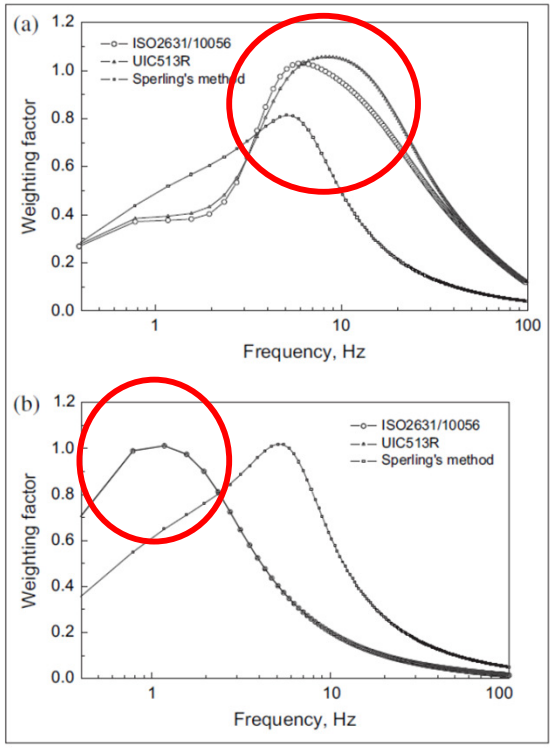
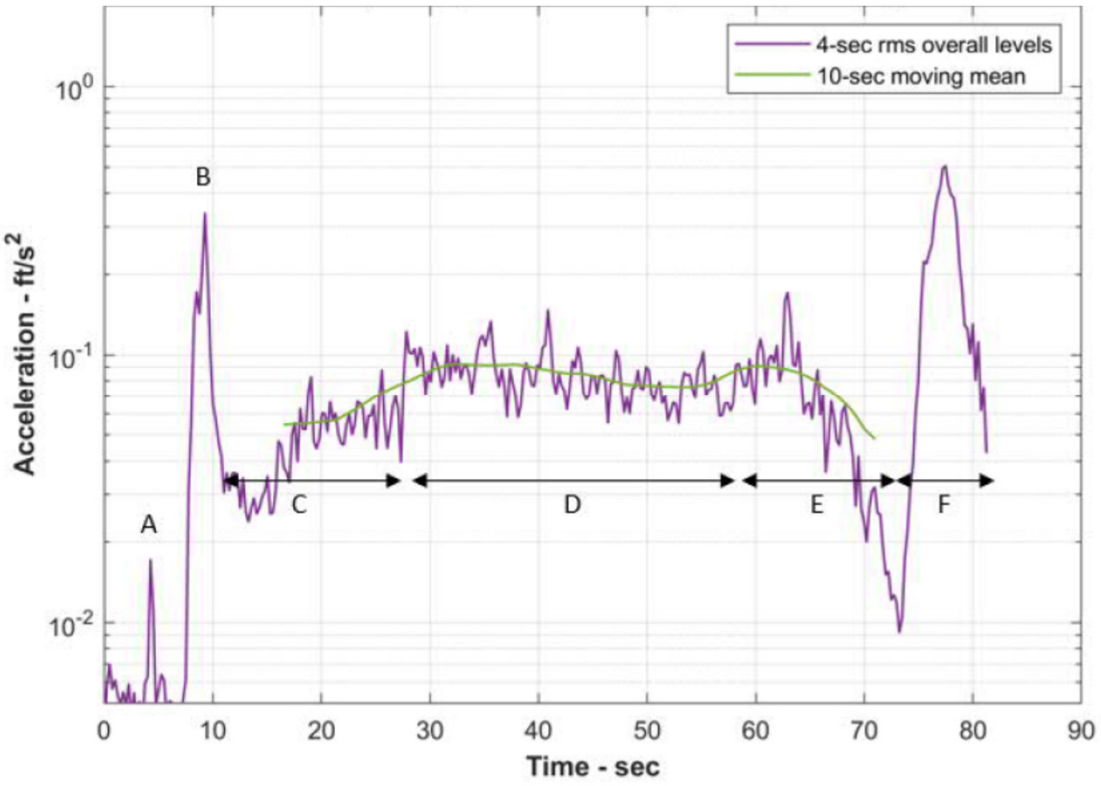


Fig. 2: Frequency weight functions for different standards: (a) vertical direction and (b) lateral and longitudinal directions

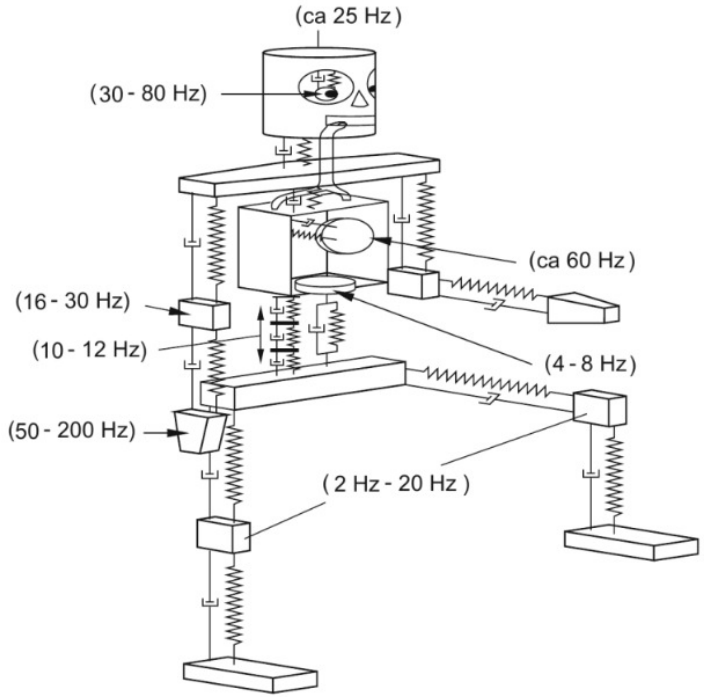
1. ISO 2631 is a ride quality methodology standard. Not a criteria standard.
2. ISO 2631 NOT rail vehicle-specific.
3. Vertical vibration has higher sensitivity between 4 Hz and 12 Hz.
4. Lateral vibration has high sensitivity between 0.5 Hz and 2 Hz.

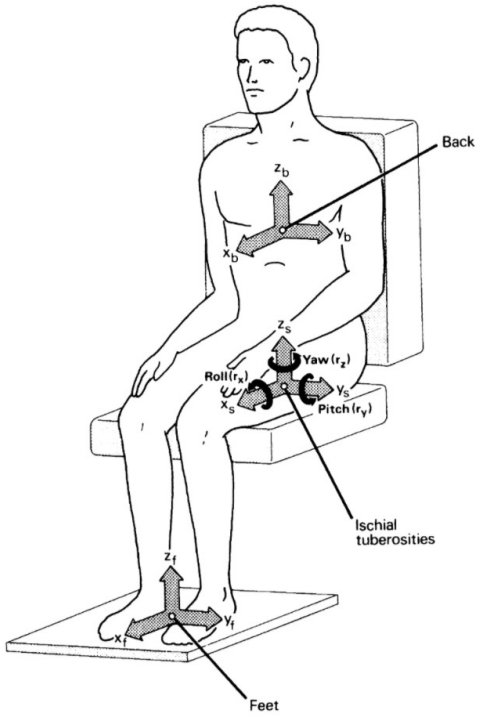
Ride Quality



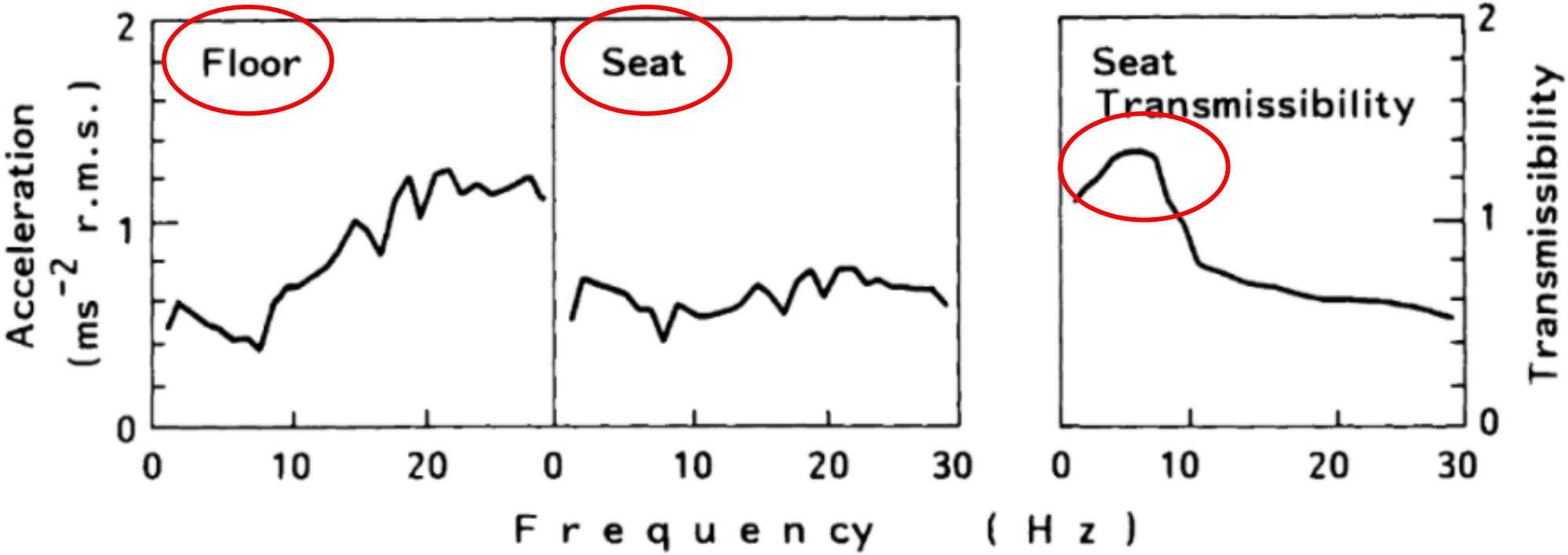
The duration to evaluate maximum value is left to practitioners discretion.

Ride Quality in Trains

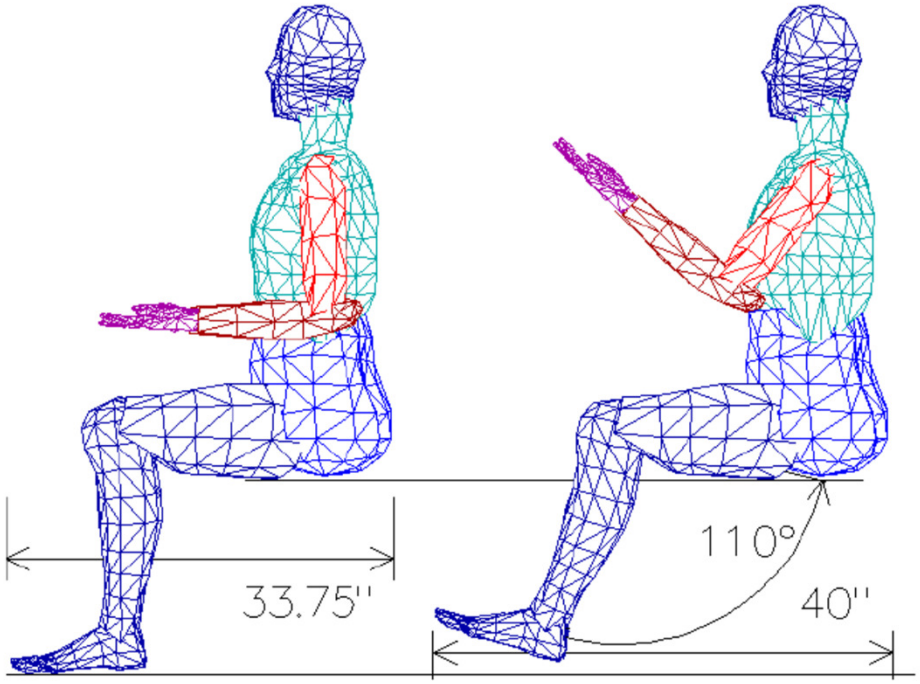




Equivalent Comfort Contour – Floor Vs Seat



LRV Seat Tests



Conclusions

1. A comprehensive wheel rail interface program is important to customize maintenance activities.
2. Systemic studies and analysis can help to optimize LRV vehicle and alignment performance.
3. Understanding the behavior of different vehicle type and track type helps to reduce the time taken to resolve noise and vibration issues.

References

- Rail Vehicle Dynamics: Klaus Knothe & Sebastian Stichel.
- Handbook of Human Vibration: M. J. Griffin.
- Handbook of Railway Vehicle Dynamics: Simon Iwnicki.
- An Experimental Study on the Ride Comfort of the Korean High-Speed Train, by Sunghoon Choi & Seog-Won Kim.