Using Wheel Impact Load Detector Data to Understand Wheel Loading Environment

  

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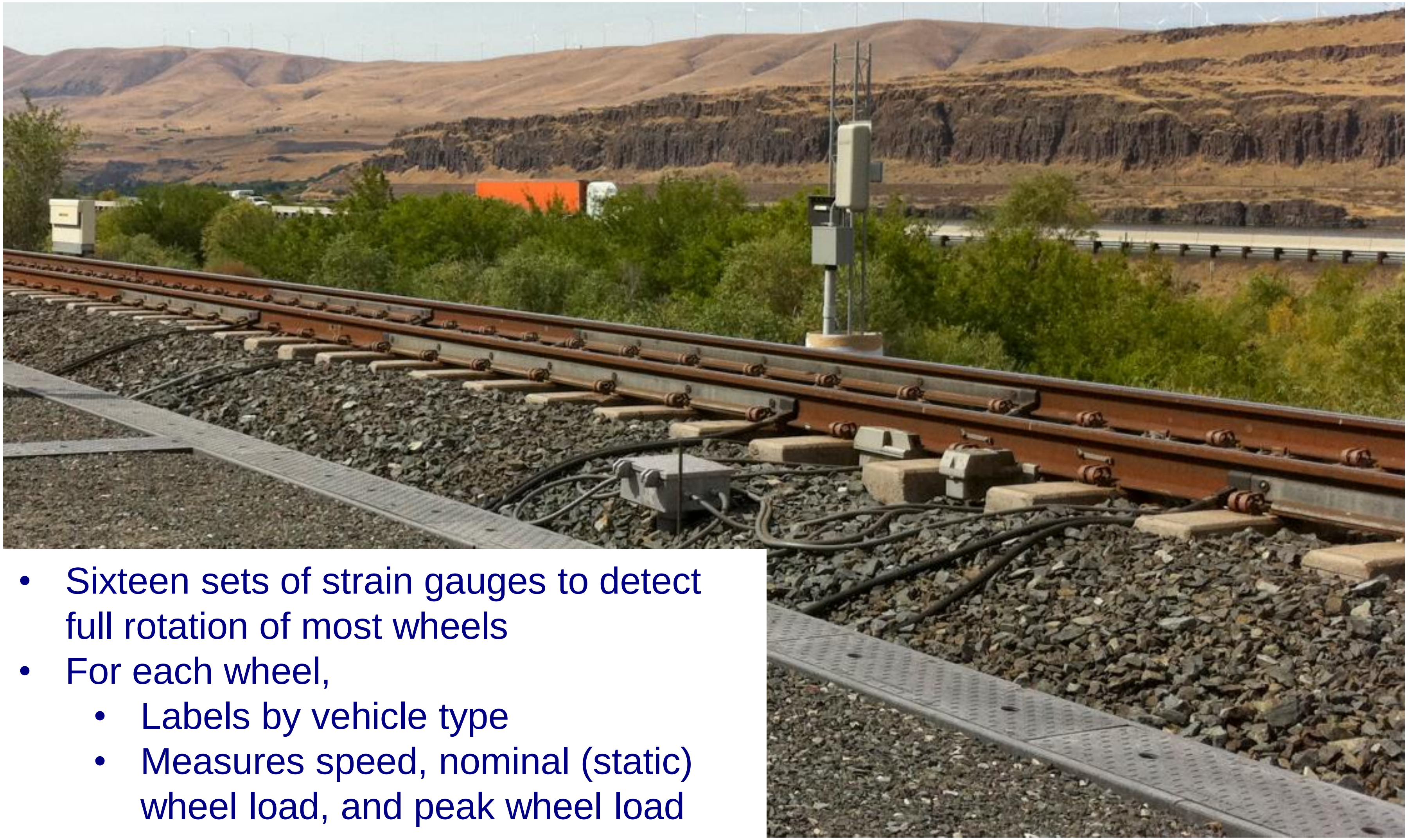
Outline

- Objectives of quantifying load amplification
- Wheel load distribution on shared infrastructure
  - Causes of load amplification
- Identification of load amplification factors
  - Dynamic wheel load factors
  - Impact factors
- Wheel loads on curved track
- Conclusions and Acknowledgements

Objectives

- Use wheel impact load detector data to understand wheel loading environment, leading to improved design of track structure that reflects actual loading demands
- Characterize and quantify increase above static wheel load due to several factors
  - Temperature
  - Speed
  - Irregularities
- Identify dynamic and impact wheel load factors
- Summarize alternative data collection methods

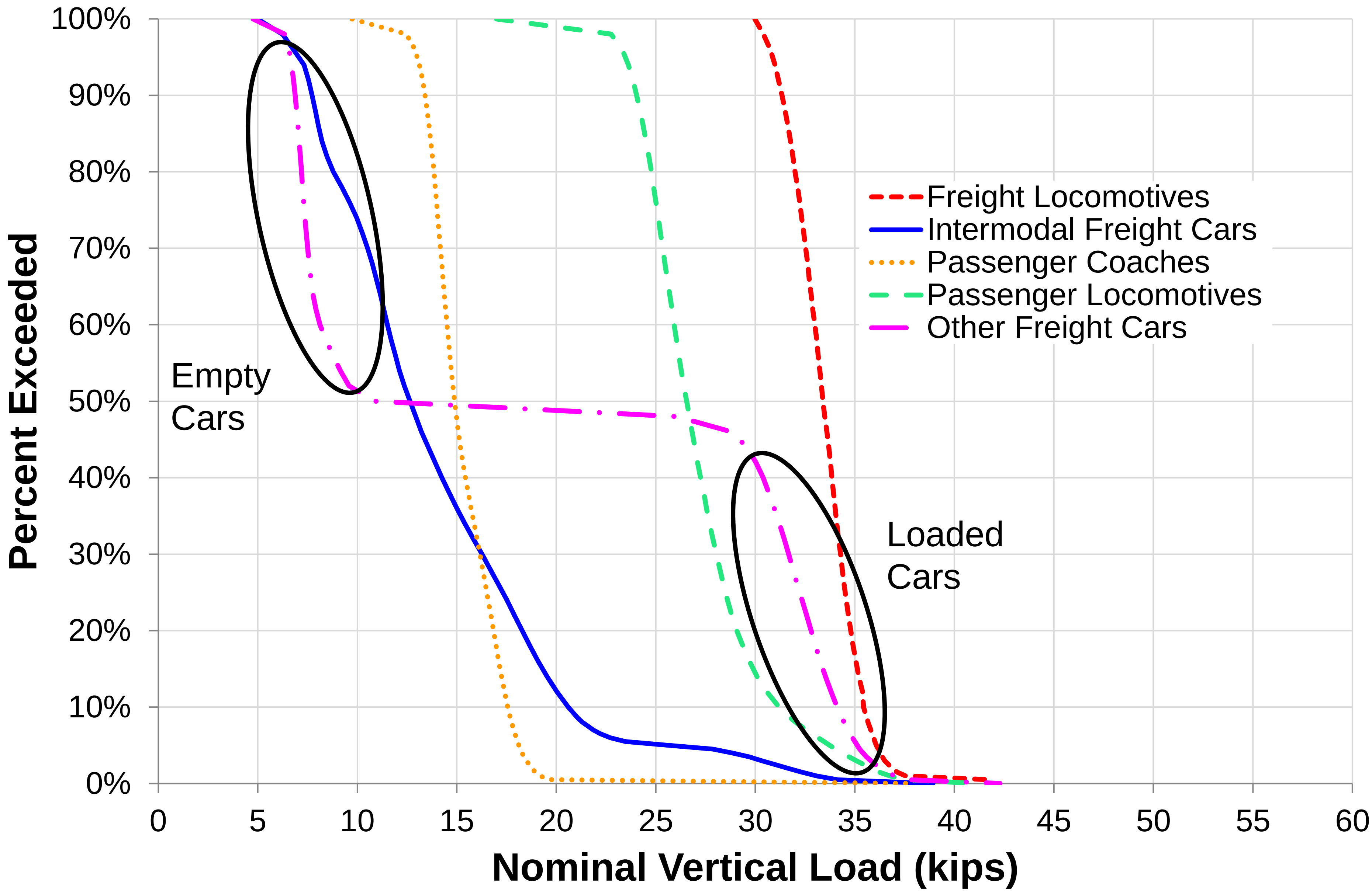
Wheel Impact Load Detectors (WILD)



- Sixteen sets of strain gauges to detect full rotation of most wheels
- For each wheel,
  - Labels by vehicle type
  - Measures speed, nominal (static) wheel load, and peak wheel load

WILD Data Provided by Amtrak and UP

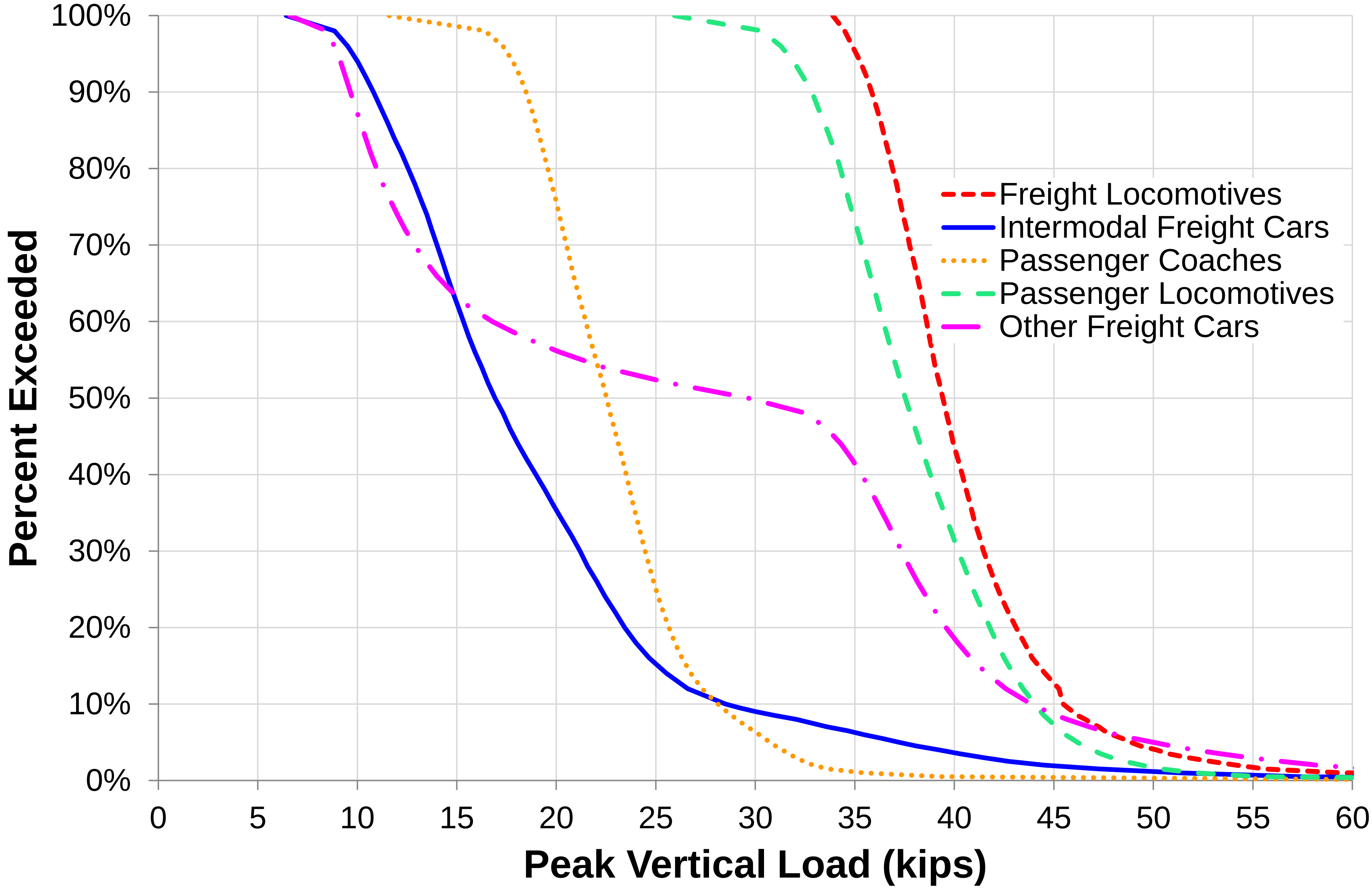
Traffic Distribution – Nominal Wheel Loads



Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN

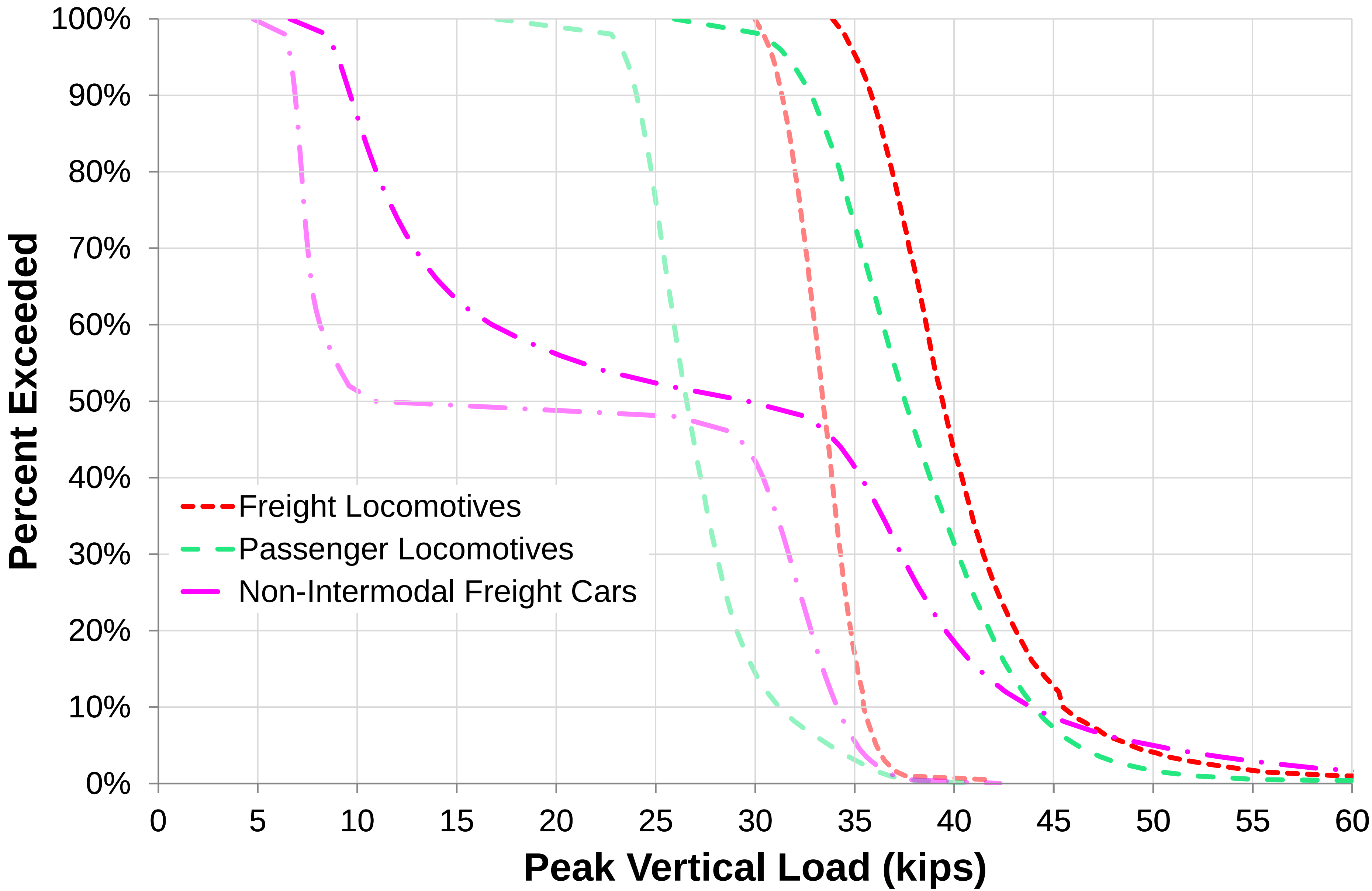
Traffic Distribution – Peak Wheel Loads



Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN

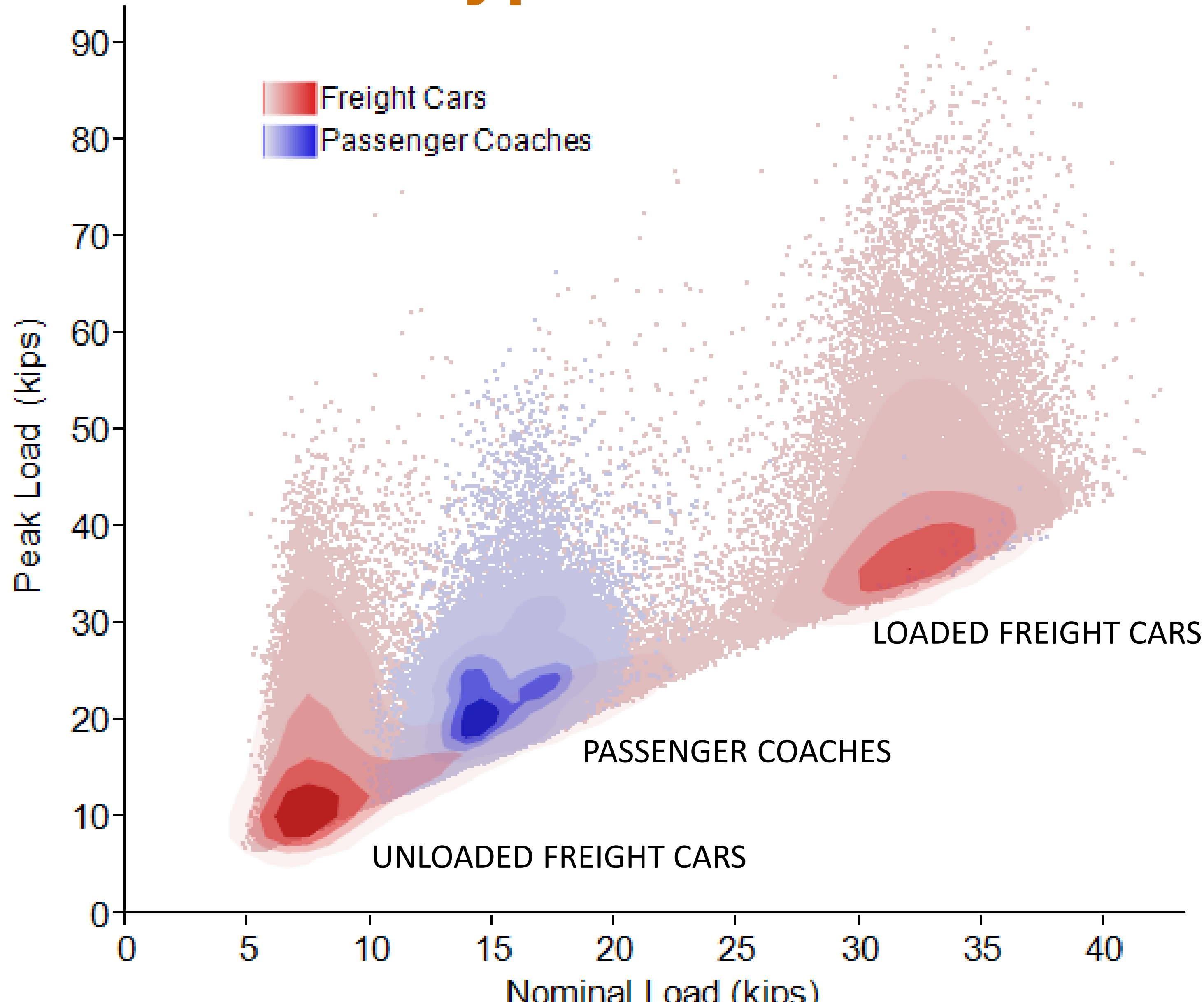
Nominal vs. Peak Vertical Load



Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN

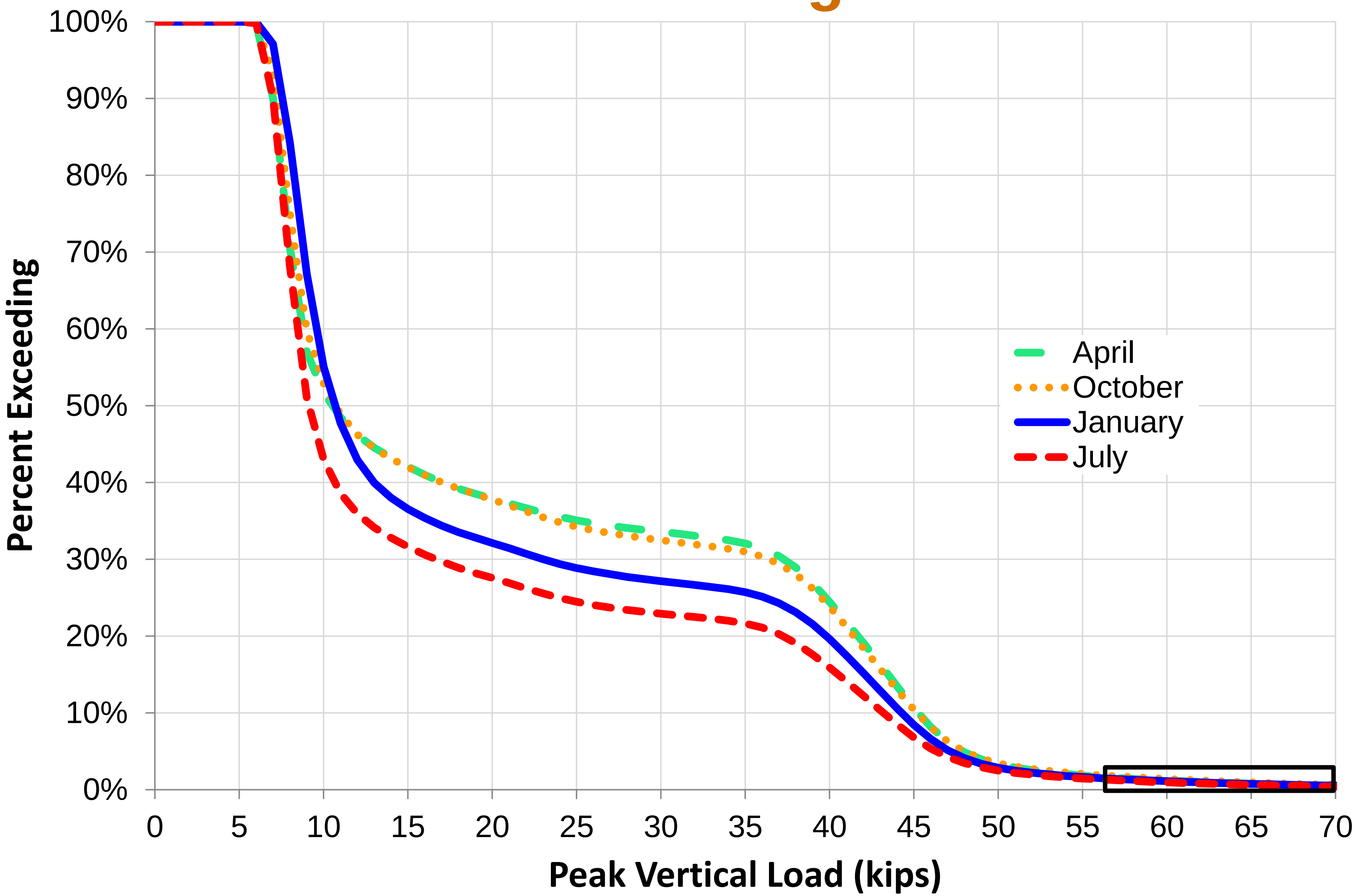
Effect of Traffic Type on Peak Wheel Load



Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN

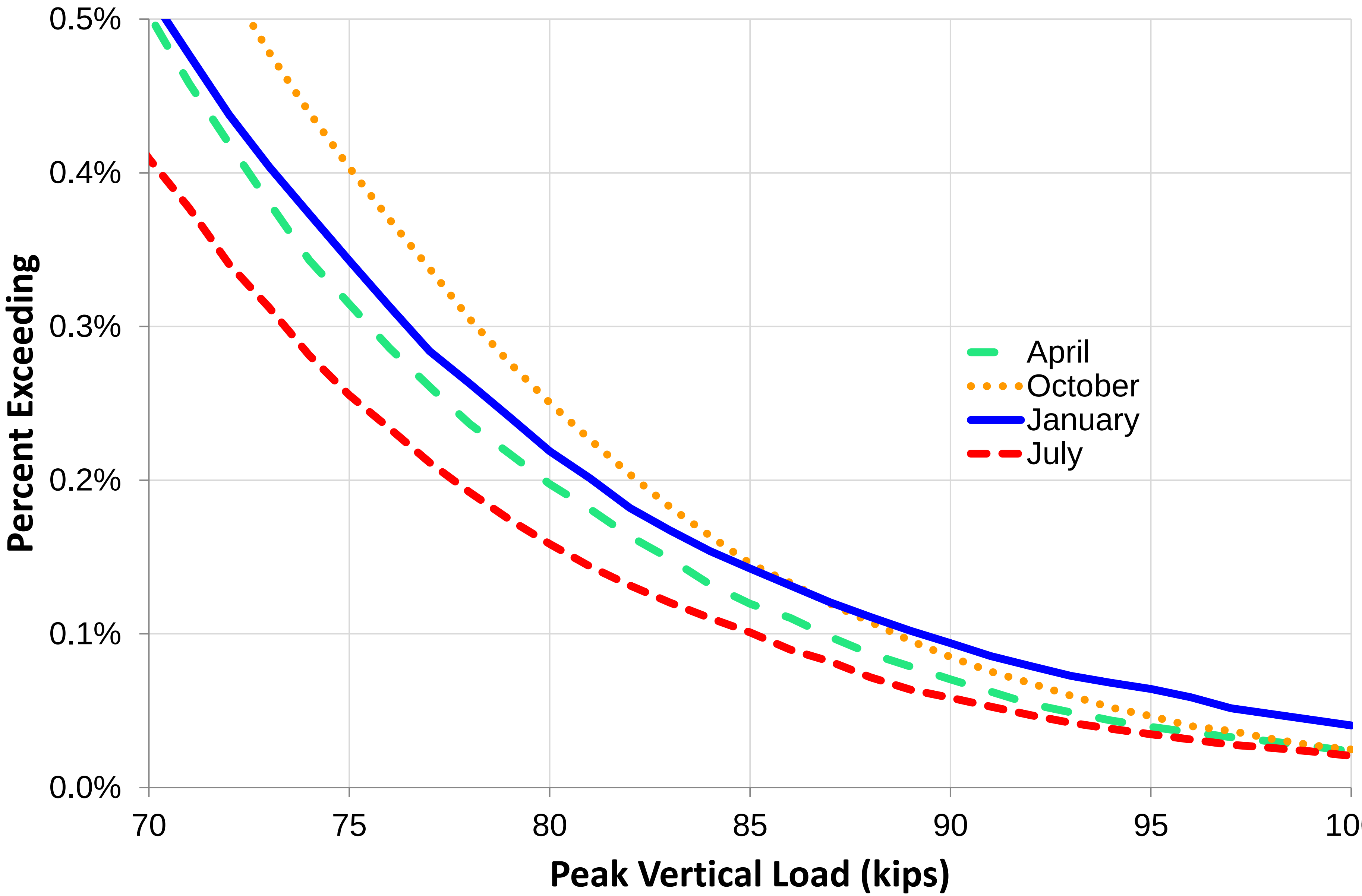
Seasonal Variation of Freight Wheel Loads



Source: Union Pacific – Gothenburg, NE (2010)

10 kips ≈ 45 kN

Seasonal Variation of Highest Freight Wheel Loads



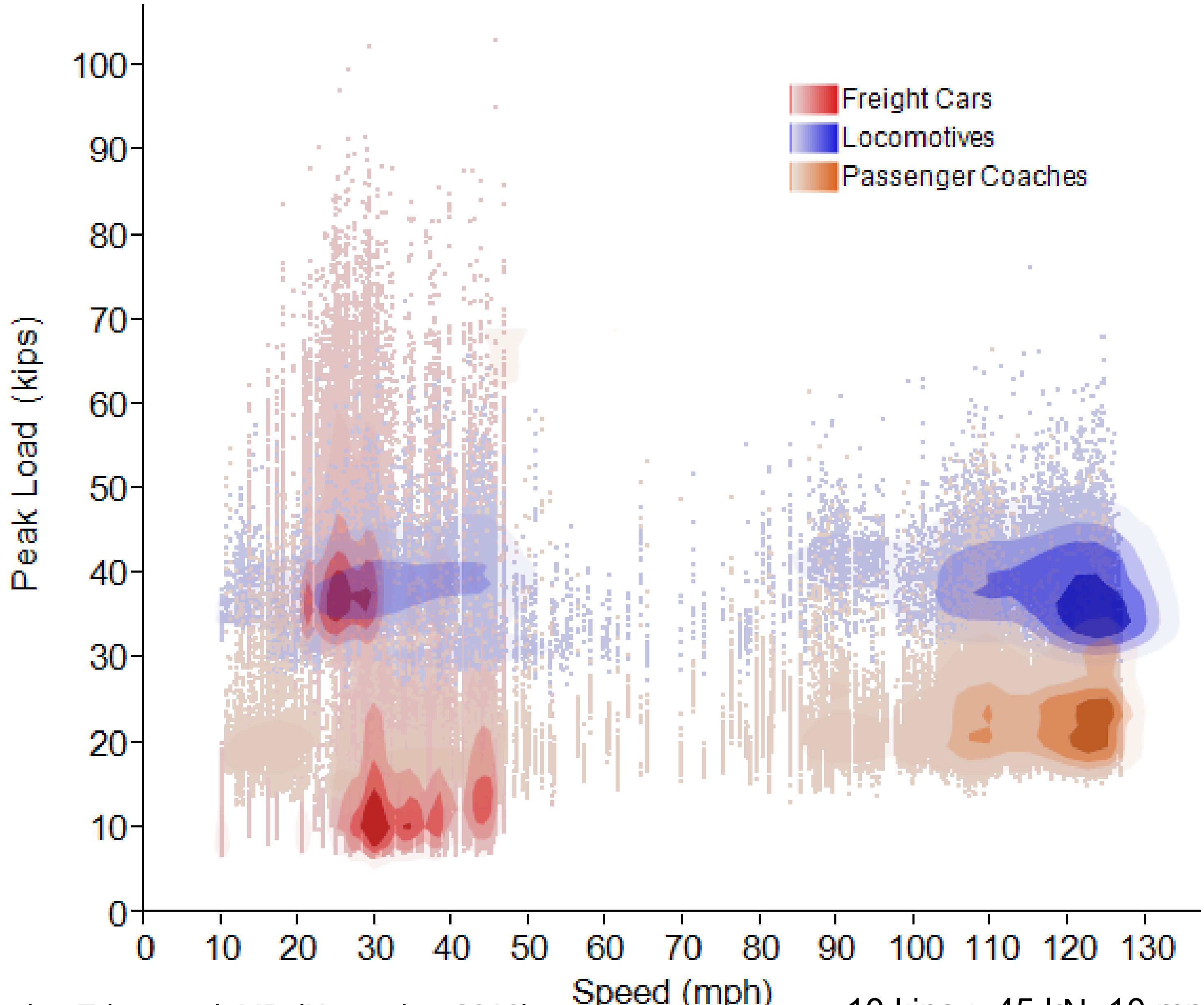
Source: Union Pacific – Gothenburg, NE (2010)

10 kips ≈ 45 kN

Dynamic vs. Impact Load

- Static load – load of vehicle at rest
- Quasi-static load – static load at speed, independent of time
- Dynamic load – high-frequency effects of wheel/rail interaction, dependent on time
  - E.g., $\boldsymbol{Dynamic\ Factor = 1 + \frac{33(speed\ (mph))}{100(diameter\ (in.))}}$
- Impact load – high-frequency and short duration load caused by track and vehicle irregularities
  - E.g., increase of 200% (found in AREMA Chapter 30)

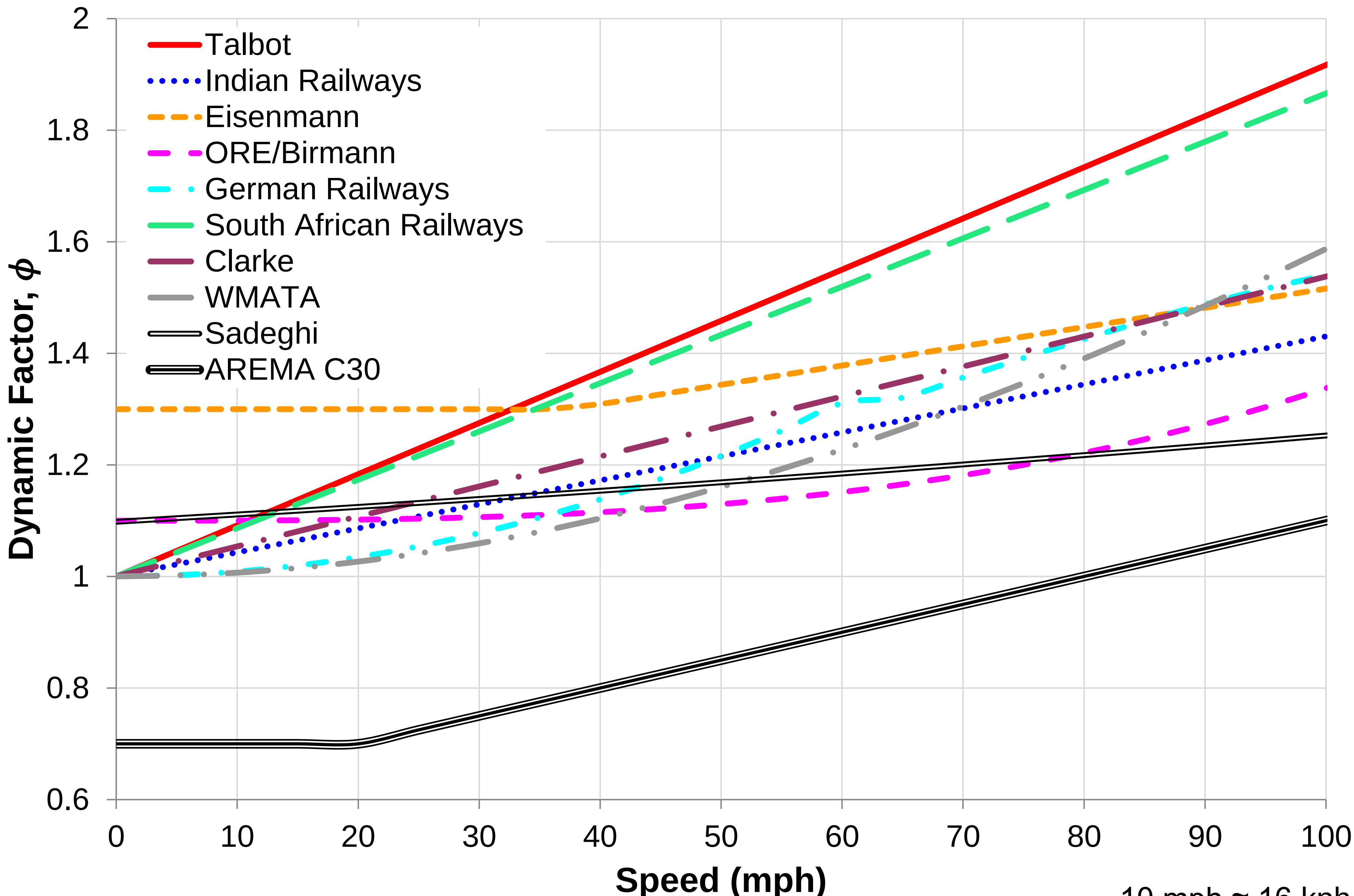
Effect of Speed on Wheel Load



Source: Amtrak – Edgewood, MD (November 2010)

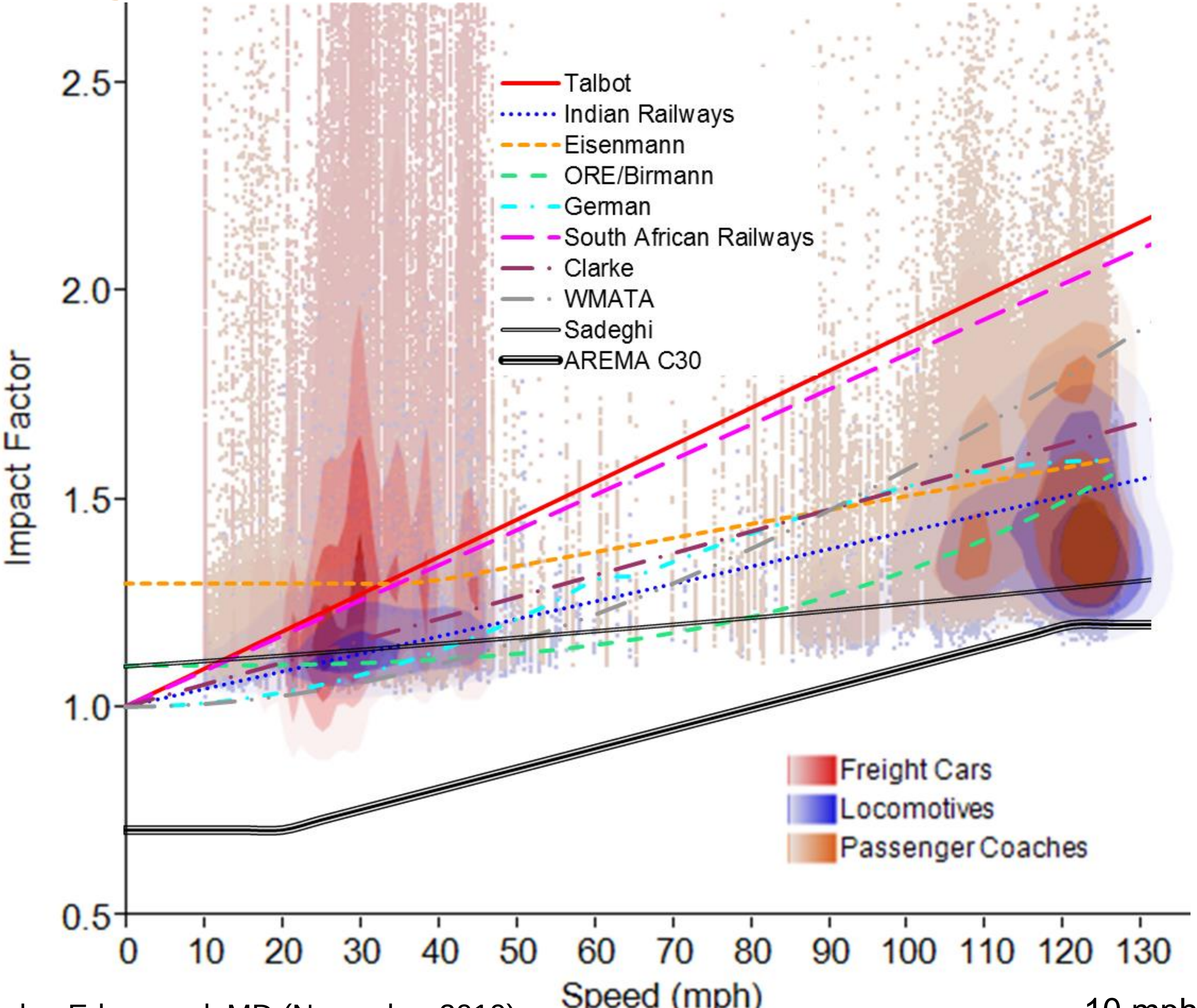
10 kips ≈ 45 kN, 10 mph ≈ 16 kph

Comparison of Dynamic Wheel Load Factors



10 mph ≈ 16 kph

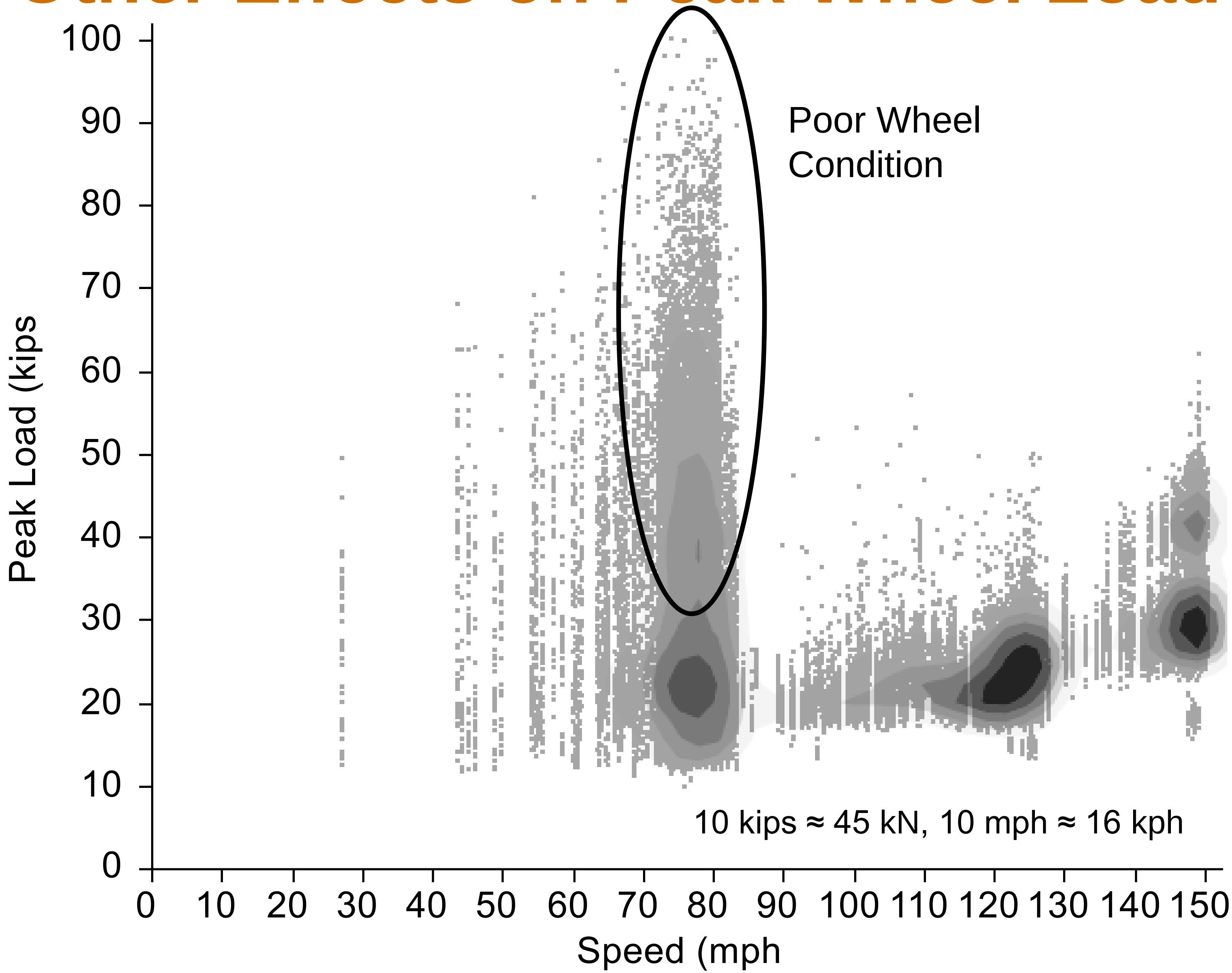
Dynamic Wheel Load Factors



Source: Amtrak – Edgewood, MD (November 2010)

10 mph ≈ 16 kph

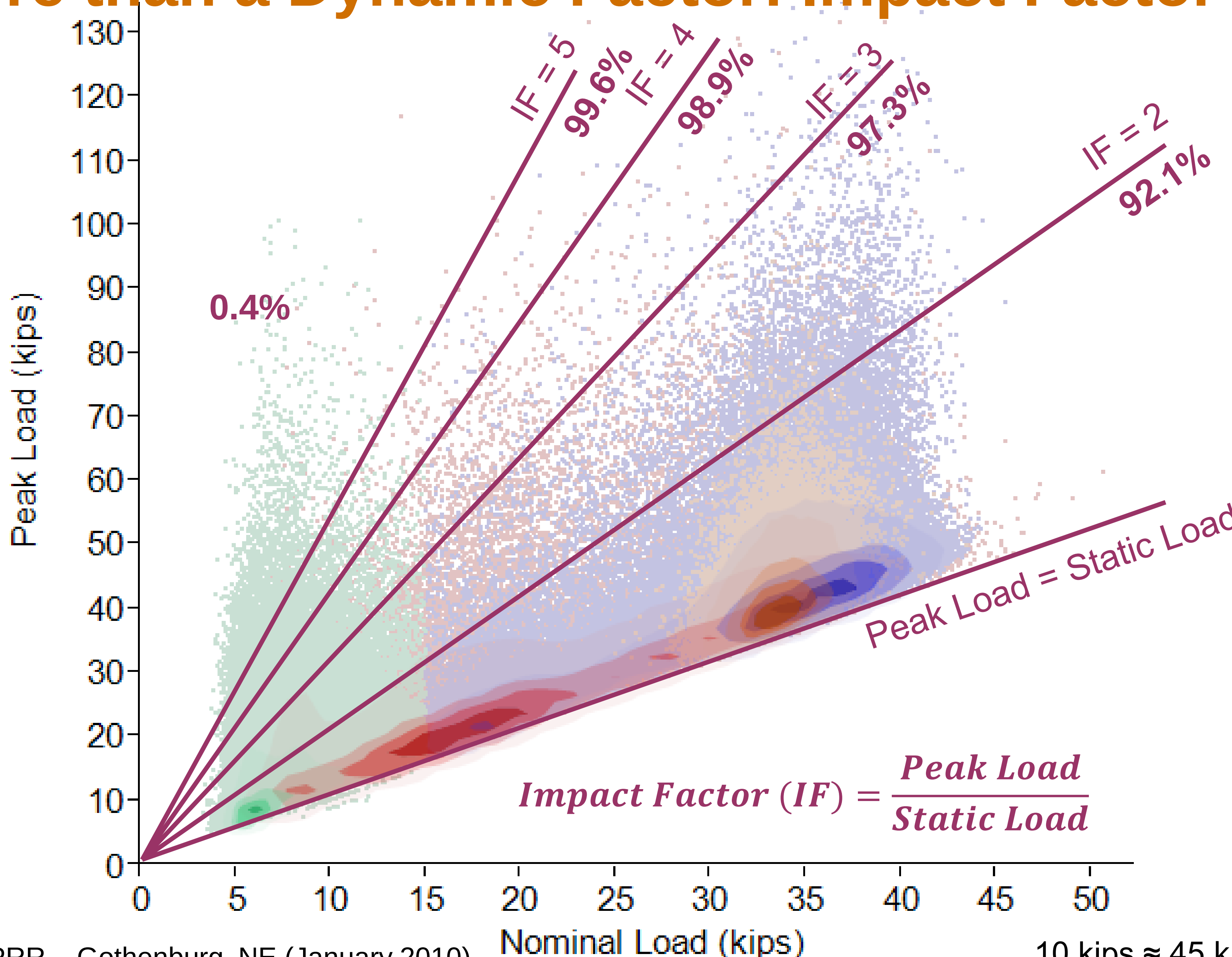
Other Effects on Peak Wheel Load



Source: Amtrak – Mansfied, MA (November 2010)

Passenger Coaches

More than a Dynamic Factor: Impact Factor



$$\text{Impact Factor } (IF) = \frac{\text{Peak Load}}{\text{Static Load}}$$

Source: UPRR – Gothenburg, NE (January 2010)

10 kips ≈ 45 kN

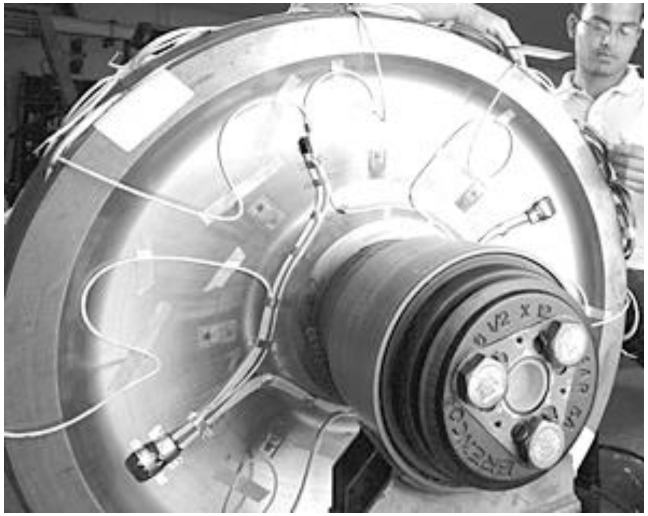
Thoughts on Impact Factor

- AREMA Chapter 30 Impact Factor (300%) exceeds majority of locomotive and loaded freight car loads
  - Greater impact factor may be necessary for lighter rolling stock (passenger coaches and unloaded freight cars)
  - Wheel condition significantly affects load
  - Speed causes highest impacts to be higher
- Evaluating effectiveness of impact factor dependent on static weight of car

Other Factors Affecting Wheel Loads

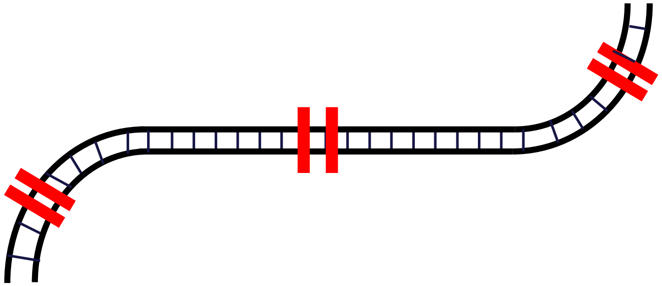
- Moisture and temperature
- Position within the train
- Curvature
- Grade
- Track quality

Need alternative data collection methods (Curvature, Grade, Track quality)



Instrumented Wheel Set

UIUC Instrumentation Plan

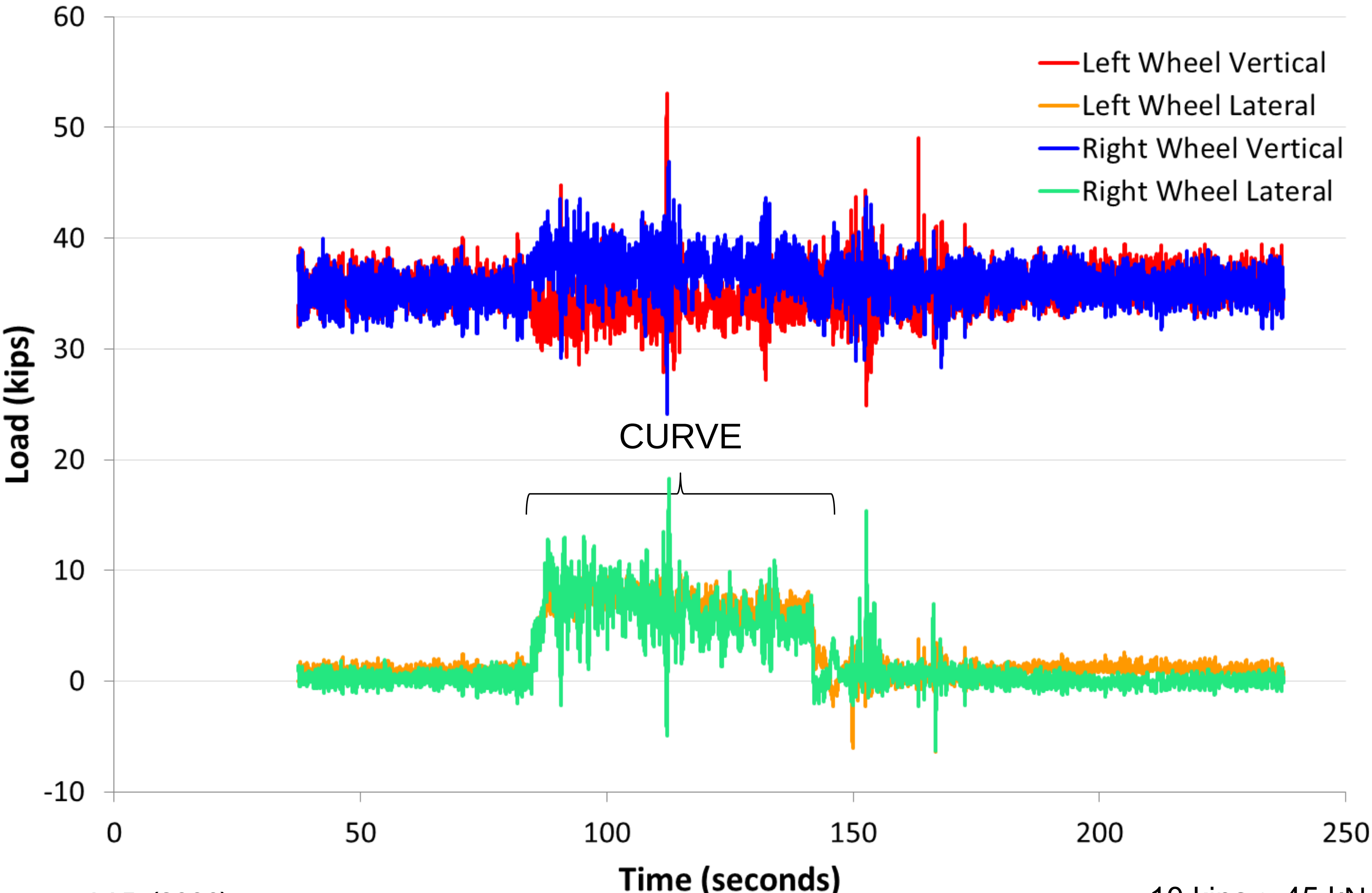


Truck Performance Detector

Alternative Data Collection Methods

- Instrumented Wheel Set
  - Vehicle-mounted; collects data at 300 Hz
  - Measures vertical and lateral loads in tangent, curved, and graded sections
- Truck Performance Detector
  - Wayside detector in tangent and curved sections
  - Measures vertical and lateral loads of each wheel
- UIUC Instrumentation Plan (thus far implemented at TTC)
  - Instrumented track in tangent and curved sections
  - Continuously measures each wheel in multiple locations for vertical load, lateral load, and various deflections

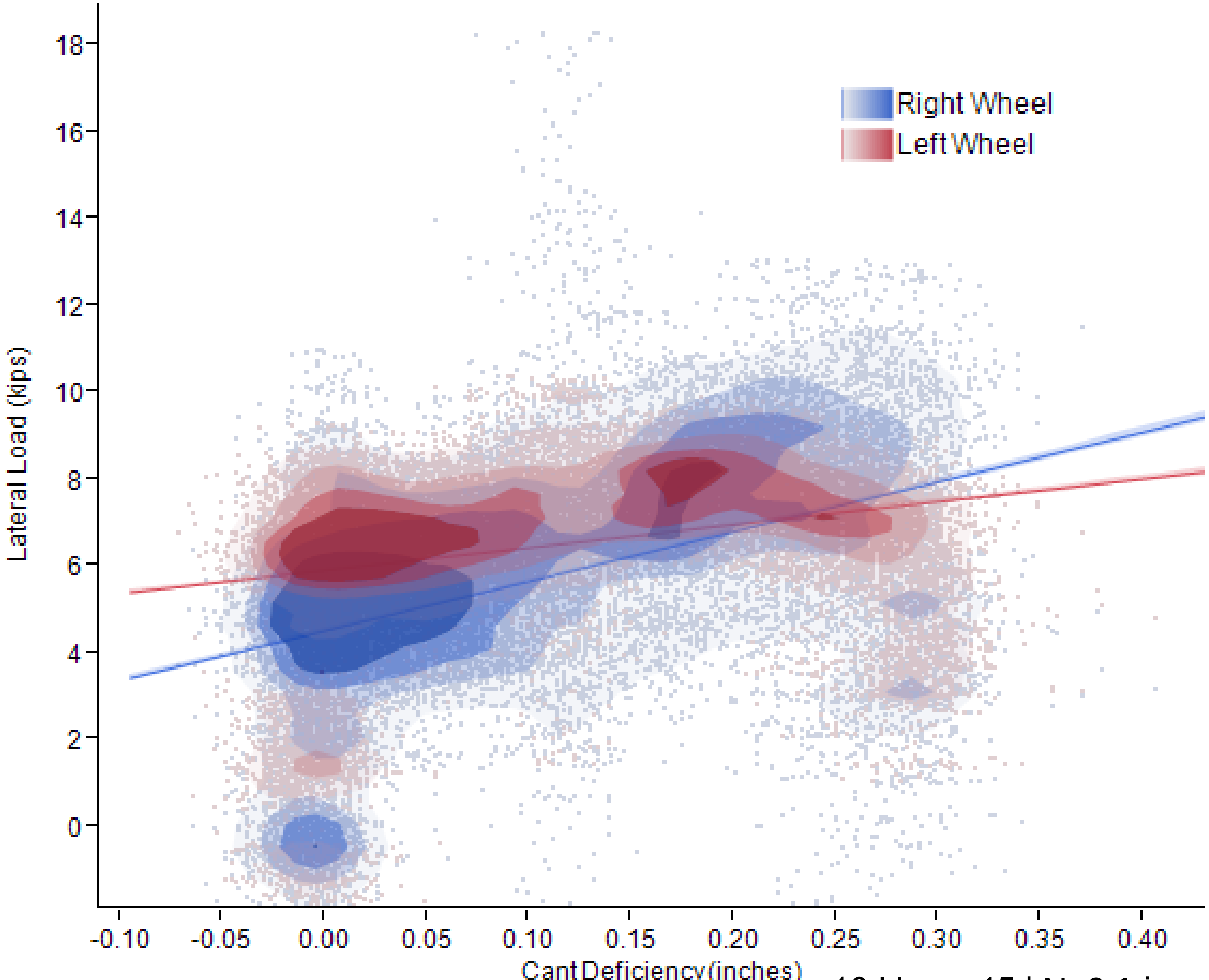
IWS: Wheel Loads on Left-Handed Curve



Source: AAR (2006)

10 kips ≈ 45 kN

Lateral Loads within Left-Handed Curve



Source: AAR (2006)

10 kips ≈ 45 kN, 0.1 in = 2.54 mm

Conclusions

- Wheel impact load detectors can be used to characterize the loading environment, leading to improved track design
- Colder temperatures do not increase the majority of the wheel loads; winter conditions do increase highest impact loads
- Dynamic and impact wheel load factors can be compared and objectively evaluated, resulting in improved decision-making in design
- The use of technology typically reserved for monitoring mechanical health can also provide increased insight into track design and maintenance

Acknowledgements

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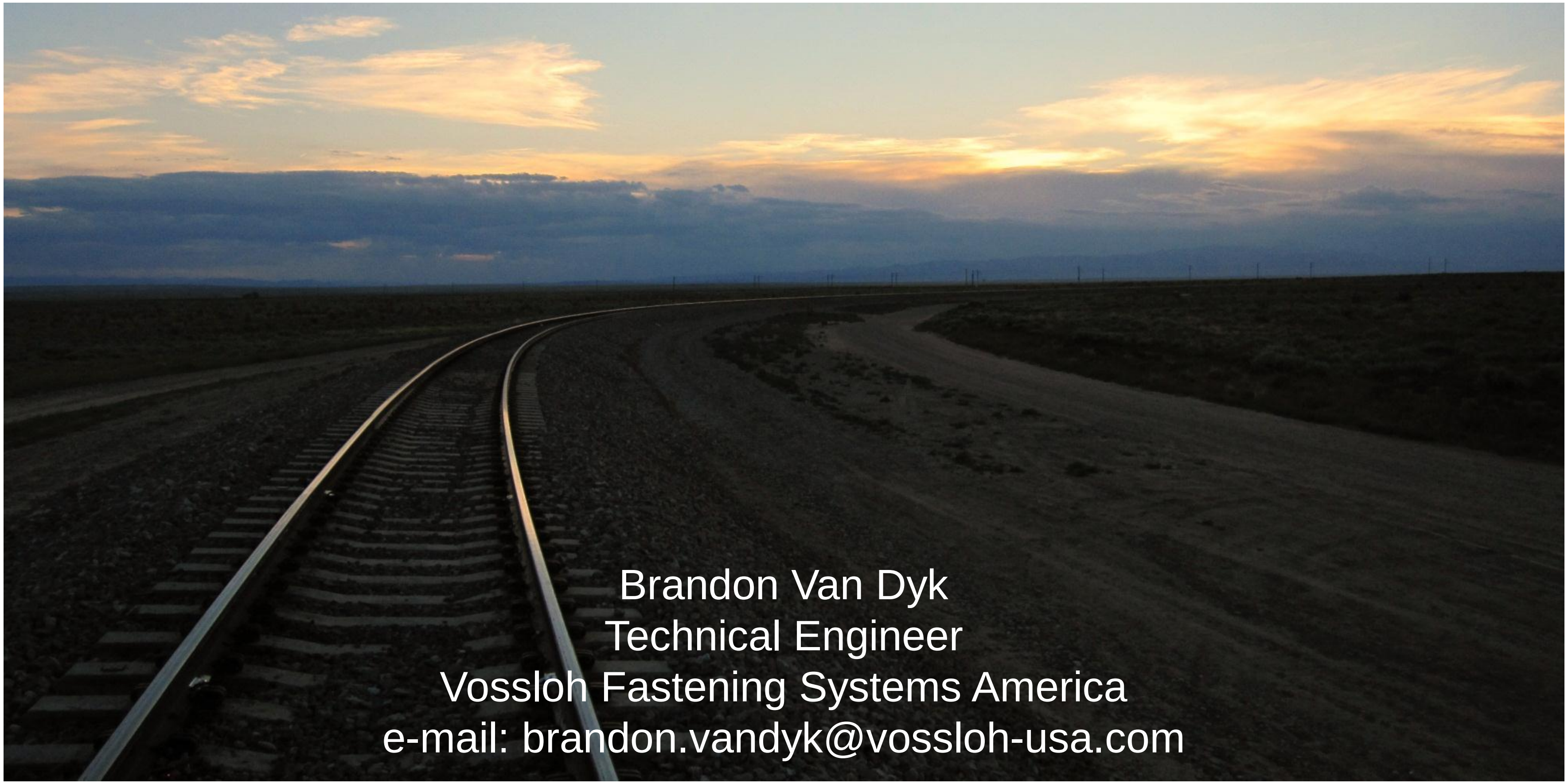
FRA Tie and Fastener BAA Industry Partners:

Questions



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