Loading Demands on North American Track

AREMA Committee 30 Meeting
Incline Village, NV
8 October 2013

Brandon J. Van Dyk, Marcus S. Dersch, J. Riley Edwards, Conrad Ruppert, Jr., and Christopher P.L. Barkan

U.S. Department of Transportation
Federal Railroad Administration
RAILTEC
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Outline

• Objectives of quantifying load amplification
• Wheel load distribution on shared infrastructure
  – Causes of load amplification
• Evaluation of load amplification factors
  – Dynamic wheel load factors
  – Impact factors
• Wheel loads on curved track
• Rail seat load calculation methodologies
• Conclusions and Acknowledgements
Objectives

• Characterize and quantify increase above static wheel load due to several factors
  – Temperature
  – Speed
  – Irregularities

• Evaluate effectiveness of dynamic and impact wheel load factors

• Determine rail seat load entering sleeper and fastening system

• Provide useful information for AREMA Manual updating and improvement
## Current Chapter 30 Loading Environment

### Table 30-1-1. Wheel to Rail Loads (kips)

<table>
<thead>
<tr>
<th></th>
<th>CURVE</th>
<th>SPEED</th>
<th>VERT</th>
<th>LAT</th>
<th>LONG</th>
<th>VERT</th>
<th>LAT</th>
<th>LONG</th>
<th>VERT</th>
<th>LAT</th>
<th>LONG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;2 DEG</td>
<td></td>
<td></td>
<td></td>
<td>2-5 DEG</td>
<td></td>
<td></td>
<td>&gt;5 DEG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAINLINE FREIGHT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>80</td>
<td>20*</td>
<td>50</td>
<td></td>
<td></td>
<td>80</td>
<td>30*</td>
<td>50</td>
<td>80</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>40 to 60</td>
<td>120</td>
<td>30*</td>
<td>50</td>
<td></td>
<td></td>
<td>120</td>
<td>30*</td>
<td>50</td>
<td>120</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>&gt;60</td>
<td>120</td>
<td>30</td>
<td>50</td>
<td></td>
<td></td>
<td>120</td>
<td>30</td>
<td>50</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>LIGHT DENSITY FREIGHT (no A/C Traction)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>80</td>
<td>20</td>
<td>30</td>
<td></td>
<td></td>
<td>80</td>
<td>30*</td>
<td>30</td>
<td>80</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>40 to 60</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td></td>
<td></td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>120</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>&gt;60</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td></td>
<td></td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>HIGH SPEED PASSENGER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;90</td>
<td>100</td>
<td>10</td>
<td>25</td>
<td></td>
<td></td>
<td>100</td>
<td>18</td>
<td>25</td>
<td>100</td>
<td>20*</td>
<td>25</td>
</tr>
<tr>
<td>&gt;90</td>
<td>100</td>
<td>18</td>
<td>25</td>
<td></td>
<td></td>
<td>100</td>
<td>18</td>
<td>25</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>TRANSIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No data available</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This data estimated or interpolated

** Generally accepted superelevation practice excludes these values
Current Chapter 30 Loading Environment

• Many of the flexural requirements for crossties use fixed input values
  – Axle load: 78 kips (347 kN)
  – Distribution factor: 0.5 (24-in. tie spacing)
  – Impact factor: 3.0
• Flexural requirements are developed using a rail seat load of 58.5 kips (260 kN)
• May lead to design that is not necessarily reflective of loading environment
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
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)
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., $\text{Dynamic Factor} = 1 + \frac{33 \text{(speed)}}{100 \text{(diameter)}}$
- 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

- Talbot
- Indian Railways
- Eisenmann
- ORE/Birmann
- German Railways
- South African Railways
- Clarke
- WMATA
- Sadeghi
- AREMA C30

Dynamic Factor, $\phi$ vs Speed (mph)

- 10 mph ≈ 16 kph
Dynamic Wheel Load Factors

Source: Amtrak – Edgewood, MD (November 2010)

10 mph ≈ 16 kph
Evaluation of Dynamic Wheel Load Factors

- Talbot
- Indian Railways
- Eisenmann
- ORE/Birmann
- German Railways
- South African Railways
- Clarke
- WMATA
- Sadeghi
- AREMA C30

Percent Exceeding
Effect of Wheel Condition on Peak Wheel Load

Source: Amtrak – Mansfied, MA (November 2010)

Passenger Coaches

10 kips ≈ 45 kN, 10 mph ≈ 16 kph
More than a Dynamic Factor: Impact Factor

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

Source: UPRR – Gothenburg, NE (January 2010)

10 kips \( \approx \) 45 kN
Intermodal Cars

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

Source: UPRR – Gothenburg, NE (January 2010)

10 kips ≈ 45 kN
Impact Factor (IF) = \frac{\text{Peak Load}}{\text{Static Load}}

Source: UPRR – Gothenburg, NE (January 2010)

10 kips ≈ 45 kN
Thoughts on Impact Factor

• 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

UIUC Instrumentation Plan

Instrumented Wheel Set

Truck Performance Detector

Need alternative data collection methods
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**
  - Instrumented track in tangent and curved sections
  - Continuously measures each wheel in multiple locations for vertical load, lateral load, and various deflections
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
## Current Chapter 30 Loading Environment

**Table 30-1-1. Wheel to Rail Loads (kips)**

<table>
<thead>
<tr>
<th>CURVE</th>
<th>&lt;2 DEG</th>
<th></th>
<th></th>
<th>2-5 DEG</th>
<th></th>
<th></th>
<th>&gt;5 DEG</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VERT</td>
<td>LAT</td>
<td>LONG</td>
<td>VERT</td>
<td>LAT</td>
<td>LONG</td>
<td>VERT</td>
<td>LAT</td>
<td>LONG</td>
</tr>
<tr>
<td><strong>SPEED</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAINLINE FREIGHT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>80</td>
<td>20*</td>
<td>50</td>
<td>80</td>
<td>30*</td>
<td>50</td>
<td>80</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>40 to 60</td>
<td>120</td>
<td>30*</td>
<td>50</td>
<td>120</td>
<td>30*</td>
<td>50</td>
<td>120</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>&gt;60</td>
<td>120</td>
<td>30</td>
<td>50</td>
<td>120</td>
<td>30</td>
<td>50</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>LIGHT DENSITY FREIGHT (no A/C Traction)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>80</td>
<td>20</td>
<td>30</td>
<td>80</td>
<td>30*</td>
<td>30</td>
<td>80</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>40 to 60</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>120</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>&gt;60</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>HIGH SPEED PASSENGER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;90</td>
<td>100</td>
<td>10</td>
<td>25</td>
<td>100</td>
<td>18</td>
<td>25</td>
<td>100</td>
<td>20*</td>
<td>25</td>
</tr>
<tr>
<td>&gt;90</td>
<td>100</td>
<td>18</td>
<td>25</td>
<td>100</td>
<td>18</td>
<td>25</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>TRANSIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No data available</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This data estimated or interpolated

** Generally accepted superelevation practice excludes these values
Peak Loading Environment

<table>
<thead>
<tr>
<th>Car Type</th>
<th>Mean</th>
<th>10%</th>
<th>50%</th>
<th>75%</th>
<th>90%</th>
<th>95%</th>
<th>97.5%</th>
<th>99.5%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unloaded Freight Car</td>
<td>10.8</td>
<td>7.4</td>
<td>9.2</td>
<td>11.2</td>
<td>15.8</td>
<td>20.5</td>
<td>26.4</td>
<td>39.7</td>
<td>100.8</td>
</tr>
<tr>
<td>Loaded Freight Car</td>
<td>42.3</td>
<td>32.6</td>
<td>42.3</td>
<td>45.6</td>
<td>49.8</td>
<td>56.2</td>
<td>65.3</td>
<td>84.7</td>
<td>156.6</td>
</tr>
<tr>
<td>Intermodal Freight Car</td>
<td>27.5</td>
<td>15.2</td>
<td>24.8</td>
<td>34.6</td>
<td>41.9</td>
<td>46.8</td>
<td>54.3</td>
<td>74.8</td>
<td>141.9</td>
</tr>
<tr>
<td>Freight Locomotive</td>
<td>42.8</td>
<td>36.9</td>
<td>41.6</td>
<td>45.3</td>
<td>50.1</td>
<td>53.9</td>
<td>57.5</td>
<td>68.8</td>
<td>109.6</td>
</tr>
<tr>
<td>Passenger Locomotive</td>
<td>38.1</td>
<td>31.1</td>
<td>36.7</td>
<td>41.5</td>
<td>46.4</td>
<td>50.0</td>
<td>53.6</td>
<td>63.4</td>
<td>94.0</td>
</tr>
<tr>
<td>Passenger Coach</td>
<td>23.2</td>
<td>17.5</td>
<td>21.7</td>
<td>25.0</td>
<td>30.2</td>
<td>35.3</td>
<td>42.9</td>
<td>58.5</td>
<td>108.8</td>
</tr>
</tbody>
</table>

Source: Union Pacific – Gothenburg, NE (January 2010), Amtrak – NEC (November 2010)
Rail Seat Load Calculation Methodologies

![Graph showing Rail Seat Load (kN) vs. Wheel Load (kips)]

- Kerr
- AREMA
- Talbot
- Eisenmann
Conclusions

• A clear distinction between dynamic and impact loads should exist

• Colder temperatures do not increase the majority of the wheel loads; stiffer subgrade does increase highest impact loads

• Various dynamic wheel load factors can be compared and evaluated

• Impact factor to account for wheel and track irregularities appropriate in many instances; requires further investigation

• Design of infrastructure (including ties and fastening systems) ought to reflect actual loading demands
Acknowledgements

U.S. Department of Transportation

Federal Railroad Administration

• Funding for this research has been provided by the Federal Railroad Administration (FRA)

• Industry Partnership and support has been provided by
  – Union Pacific Railroad
  – BNSF Railway
  – National Railway Passenger Corporation (Amtrak)
  – Amsted RPS / Amsted Rail, Inc.
  – GIC Ingeniería y Construcción
  – Hanson Professional Services, Inc.
  – CXT Concrete Ties, Inc., LB Foster Company
  – TTX Company

• For assistance in data acquisition
  – Steve Crismer, Jonathan Wnek (Amtrak)
  – Steve Ashmore, Bill GeMeiner, Michael Pfeifer (Union Pacific)
  – Teever Handal, (PRT), Kevin Koch (TTCl), Jon Jeambey (TTX)

• For assistance in data processing and interpretation
  – Alex Schwarz, Andrew Stirk, Anusha Suryanarayanan (UIUC)
Questions

Brandon Van Dyk
Technical Engineer
Vossloh Fastening Systems America
e-mail: brandon.vandyk@vossloh-usa.com

J. Riley Edwards
Senior Lecturer and Research Scientist
Rail Transportation and Engineering Center – RailTEC
University of Illinois at Urbana-Champaign
e-mail: jedward2@Illinois.edu
Appendix
Distribution of Nominal Wheel Loads

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN, 10 mph ≈ 16 kph
Distribution of Peak Wheel Loads

Source: Amtrak – Edgewood, MD (November 2010)

10 kips ≈ 45 kN, 10 mph ≈ 16 kph
Variation of Loads on Amtrak’s Northeast Corridor

Source: Amtrak (April 2011)
Future Work

• Further utilize IWS and UIUC data for lateral load information on curved and graded track
• Evaluate Chapter 30 tonnage factor using “dynamic” or “actual” tonnage
• Develop numerical model to predict loading environment
Loading Demands on North American Track

Source: Amtrak – Edgewood, MD (November 2010)
Variation of Loads on Amtrak’s Northeast Corridor

Source: Amtrak (April 2011)
Variation of Loads on Amtrak’s Northeast Corridor

Source: Amtrak (April 2011)
Effect of Traffic Type on Wheel Load

Source: Amtrak – Mansfield, MA (November 2010)
Impact Factor = 1 + \frac{33(speed)}{100(diameter)}

Source: Amtrak – Edgewood, MD (November 2010)
Loading Demands on North American Track

Source: Amtrak – Edgewood, MD (November 2010)
**Effect of Speed on Impact Factor**

\[ \text{Impact Factor} = 1 + \frac{33 \times \text{speed}}{100 \times \text{diameter}} \]

27% and 73%

Source: Amtrak – Mansfield, MA (November 2010)
Comparison of Dynamic Wheel Load Factors

Dynamic Wheel Load Factor vs. Speed (mph)

- Red line: Talbot/Hay
- Blue dotted line: Indian Railways
- Orange line: Eisenmann
- Green dashed line: Birmann

The graph compares the dynamic wheel load factors for different systems at various speeds, highlighting the impact of speed on the load factors.
Loading Demands on North American Track

Tonnage Per Annum - Million Gross Tons (MGt)

Source: AREMA Manual, Figure 30-4-4
Effect of Static Load on Impact Factor – Mansfield, MA

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

Source: Amtrak – (November 2010)
Impact Loads – Edgewood, MD

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

Source: Amtrak – (November 2010)
Impact Loads – Mansfield, MA

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

Source: Amtrak – (November 2010)
Variation of Freight Wheel Loads

Source: Union Pacific – Gothenburg, NE (January 2010)
Variation of Freight Wheel Loads

Source: Union Pacific – Gothenburg, NE (January 2010)
Variation of Highest Freight Wheel Loads

Source: Union Pacific – Gothenburg, NE (January 2010)
Load Environment
AREMA Chapter 30 Section 1.2

- **Existing Content:**
  - Expected vertical, lateral, longitudinal loads at wheel/rail interface
  - Table 30-1-1 shows effects of traffic type, speed, and curvature

- **Proposed Improvements:**
  - Generally update based on current loading conditions
  - Complete areas where data are “estimated or interpolated”
  - Provide clearer definition and description of expected loads

- **Methodology:**
  - Use of existing wheel impact load detector (WILD) and instrumented wheel set (IWS) data
  - Define dynamic and impact loads based on data evidence

- **Timeline:**
  - Submit to full committee for ballot (Spring 2013)
**SECTION 1.2 LOAD ENVIRONMENT**

Table 30-1-1 defines the load environment expected to be encountered in North American Freight, High Speed Passenger and Transit Railroad segments of the industry. Specifically, Table 30-1-1 presents the available data in terms of vertical, horizontal and longitudinal loads that can be expected at the wheel/rail interface. The service categories are distinguished as follows.

Mainline Freight represents lines other than Light Density Freight. Light Density Freight represents lines with less than five million gross tons and excludes A/C Traction. High Speed Passenger represents passenger loadings whether in mixed service or on dedicated routes. Speeds are given in miles per hour.

**Table 30-1-1. Wheel to Rail Loads (kips)**

<table>
<thead>
<tr>
<th>CURVE</th>
<th>&lt;2 DEG</th>
<th>2-5 DEG</th>
<th>&gt;5 DEG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VERT</td>
<td>LAT</td>
<td>LONG</td>
</tr>
<tr>
<td>SPEED</td>
<td>LAT</td>
<td>LONG</td>
<td>VERT</td>
</tr>
<tr>
<td>MAINLINE FREIGHT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>80</td>
<td>20*</td>
<td>50</td>
</tr>
<tr>
<td>40 to 60</td>
<td>120</td>
<td>30*</td>
<td>50</td>
</tr>
<tr>
<td>&gt;60</td>
<td>120</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>LIGHT DENSITY FREIGHT (no A/C Traction)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>80</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>40 to 60</td>
<td>120</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>&gt;60</td>
<td>120</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>HIGH SPEED PASSENGER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;90</td>
<td>100</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>&gt;90</td>
<td>100</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>TRANSIT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No data available</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This data estimated or interpolated

** Generally accepted superelevation practice excludes these values
Speed Characterization – Edgewood, MD

Source: Amtrak – (November 2010)
Speed Characterization – Gothenburg, NE

Source: Union Pacific – January 2010
Seasonal Effects on Peak Vertical Load – Edgewood, MD

Source: Amtrak
Seasonal Effects on Peak Vertical Load – Edgewood, MD

Source: Amtrak
Seasonal Effects on Peak Vertical Load – Mansfield, MA

Source: Amtrak
Variations of Peak Vertical Load by Traffic – Edgewood, MD

Source: Amtrak (November 2010)
Vertical Wheel Loads – Mansfield, MA

Source: Amtrak – Mansfield, MA (November 2010)
Distribution of Passenger Wheel Loads

Source: Amtrak – November 2010
Effect of Traffic Type on Static Wheel Load

Source: Amtrak – Edgewood, MD (November 2010)
Load Effects on Impact Factor – Edgewood, MD (November 2010)
Effect of Speed on Lateral Load – Edgewood, MD (November 2010)
Effect of Speed on L/V Ratio – Edgewood, MD (November 2010)
Frequency of Peak Vertical Loads

Source: Union Pacific – Gothenburg, NE (January 2010)
Where the WILD Things Are

- Mansfield, MA (1)
- Enfield, CT (2)
- Hook, PA (3)
- Edgewood, MD (4)

Source: University of Virginia
Union Pacific Railroad Current and Proposed WILD Site Locations

- Fields
- Sunset
- Wister
- Chamberlin
- Donaldson
- Stuttgart
- Millican
- Elton

All Sites (With the Exception of Fields, OR) Provide Vertical and Lateral Measurements

- In Service WILD Locations
- Parsons Sub WILD Under Construction
- Proposed WILD Installations - 2008 and Beyond
- Truck Performance Detector (TPD) Location(s)
Loading Demands on North American Track

Distance (feet)

L/V Force Ratio

#60 A L/V (L)

#60 B L/V (R)