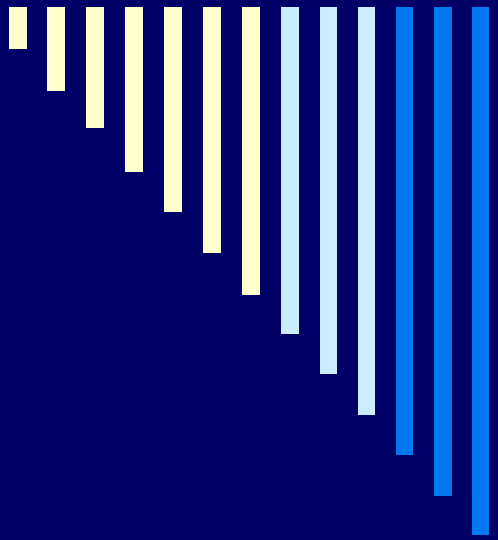


Noise, Vibration and EMI from Modern Streetcars

Hugh Saurenman, ATS Consulting
Lara York, Abbie Gregg Incorporated

What is a modern streetcar?

- Shared ROW with vehicular traffic
- Easy on/easy off for passengers
- Urban areas
- Low speed operation
- Lightweight vehicles

Examples

- Modern Systems
  - Portland
  - Tacoma
  - Paris
- Older Systems
  - Toronto Transit
  - SF Muni
  - SEPTA Surface/Subway Trolley
- New systems considered or under study for Tucson, Albuquerque, Sacramento, Madison, WI, Miami, and many other cities

Modern vs. Historic Streetcar

- PCC* vehicle on left, relatively low vibration levels
- Milan streetcar on right, relatively high vibration
- Impacts vary widely with historic vehicles
- Modern vehicles are low floor for faster loading/unloading

*Presidents' Conference Committee car introduced in the 1930's.

Advantages

- Inexpensive
- Straightforward construction
- Existing roadways
- Minimal environmental impact???

EMI Issues (AGI)

- Sensitive Equipment (particularly microscopy equipment used for research)
- …
- …

EMI Testing in Portland

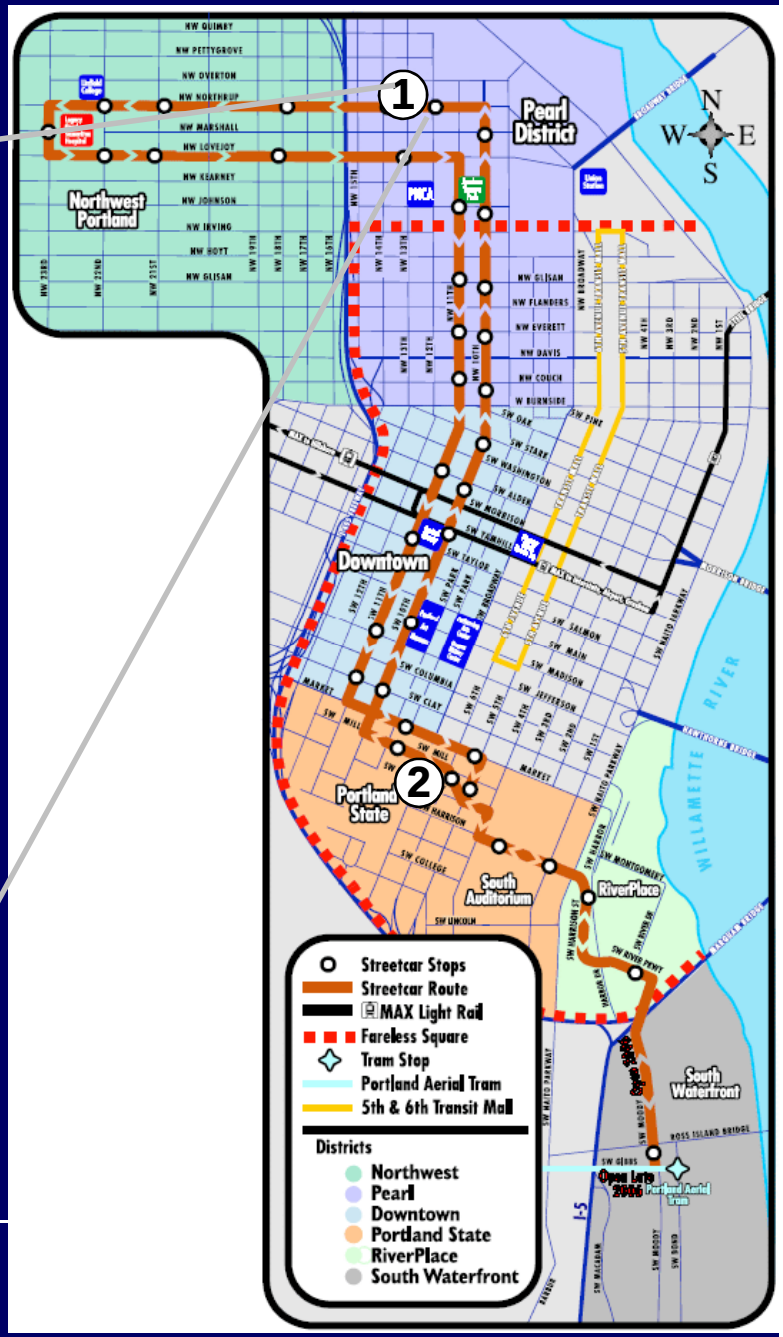
Test Results (EMI)

Potential EMI Problems for Modern Streetcar Systems

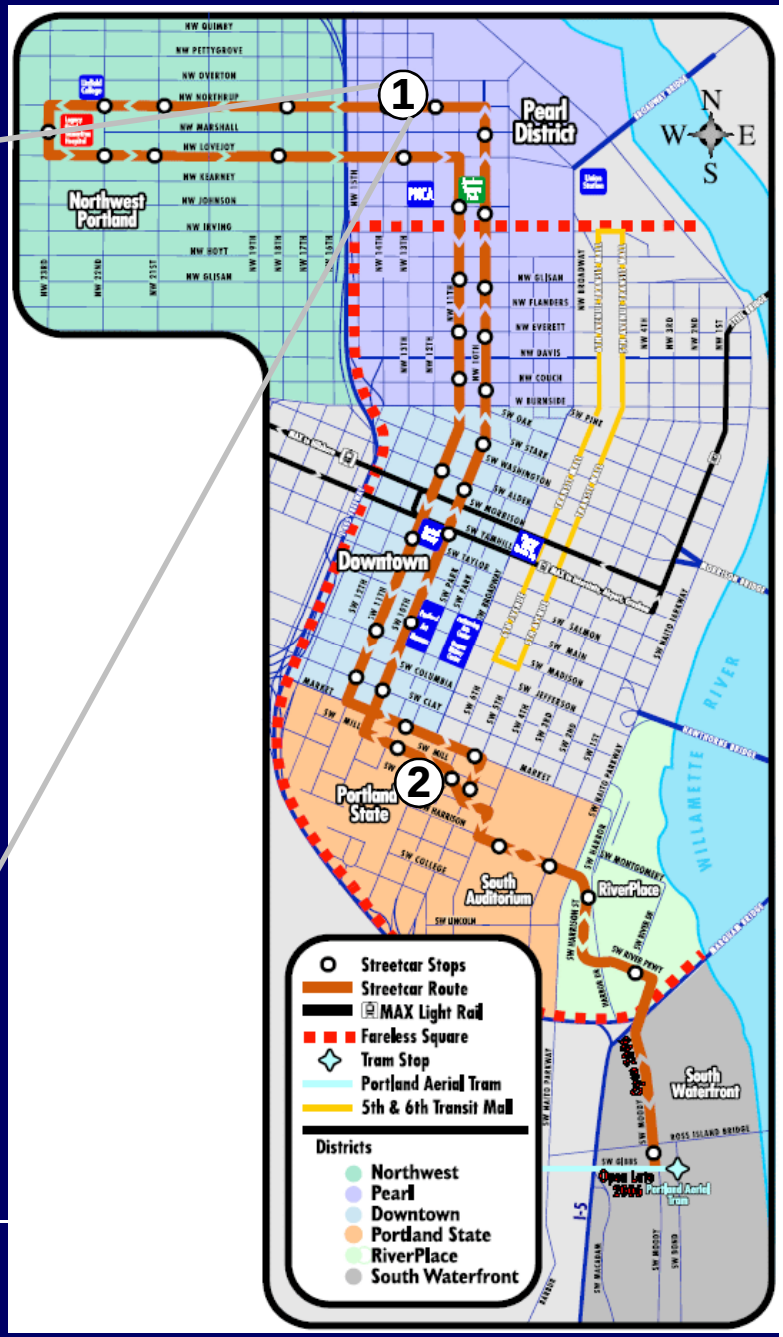
Characterizing Noise and Vibration

- Test of Škoda Vehicle (Portland, OR)
  - Passby Noise
  - Passby Vibration
- Vibration propagation
  - Portland
  - Tucson

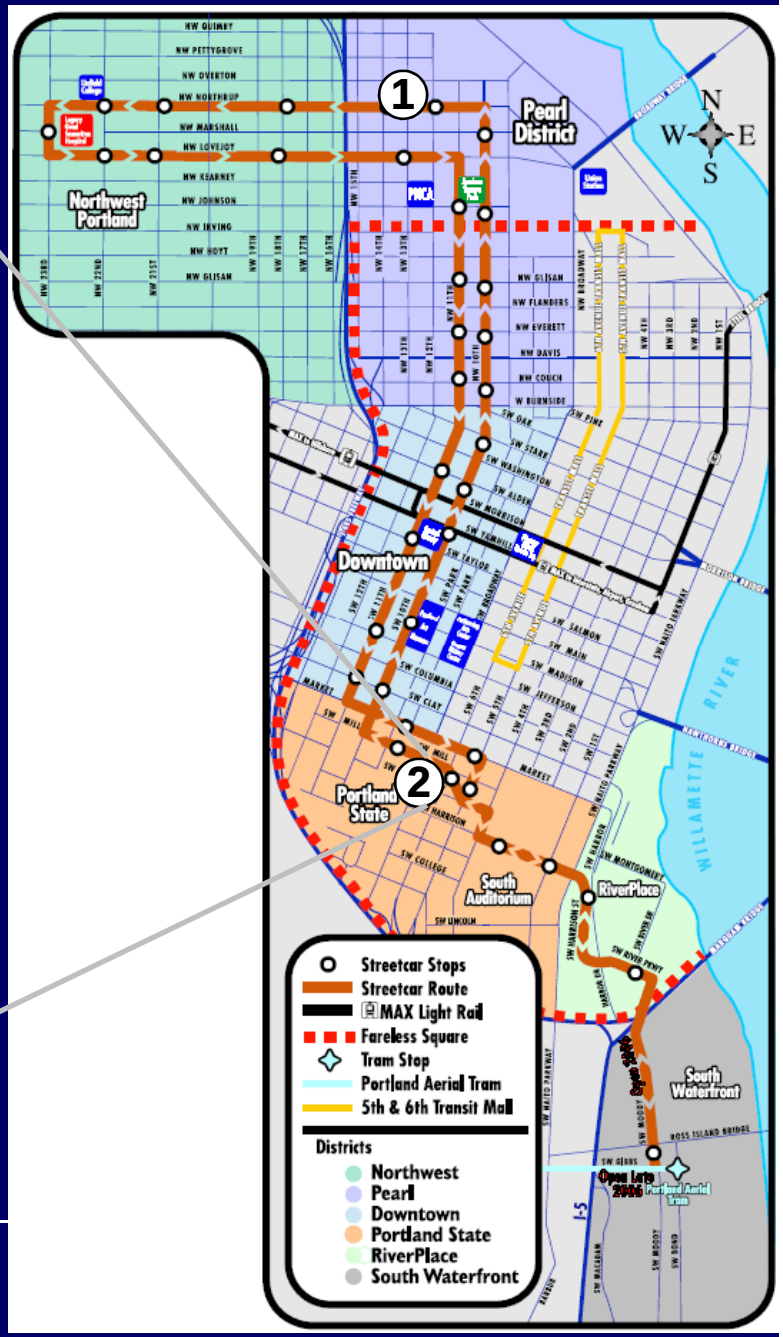
Portland Streetcar Test Sites



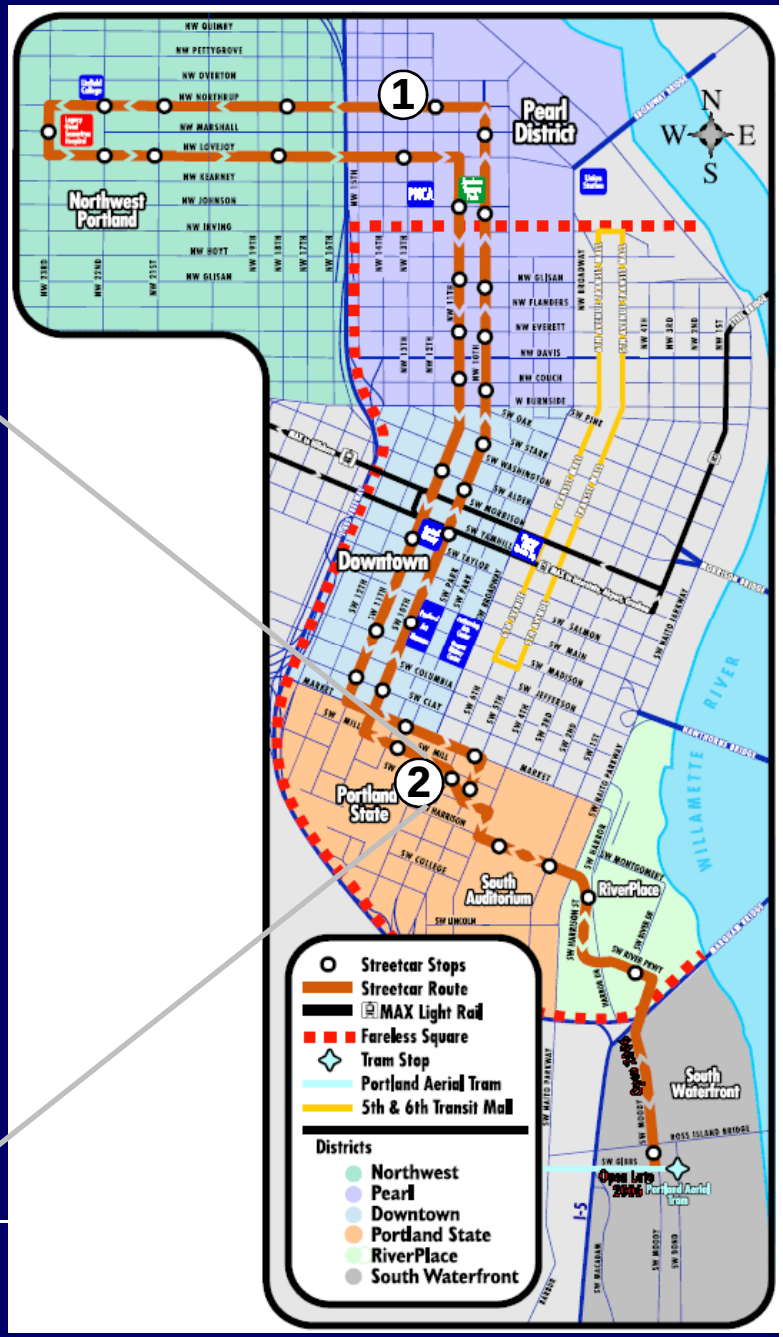
Portland Streetcar Test Sites



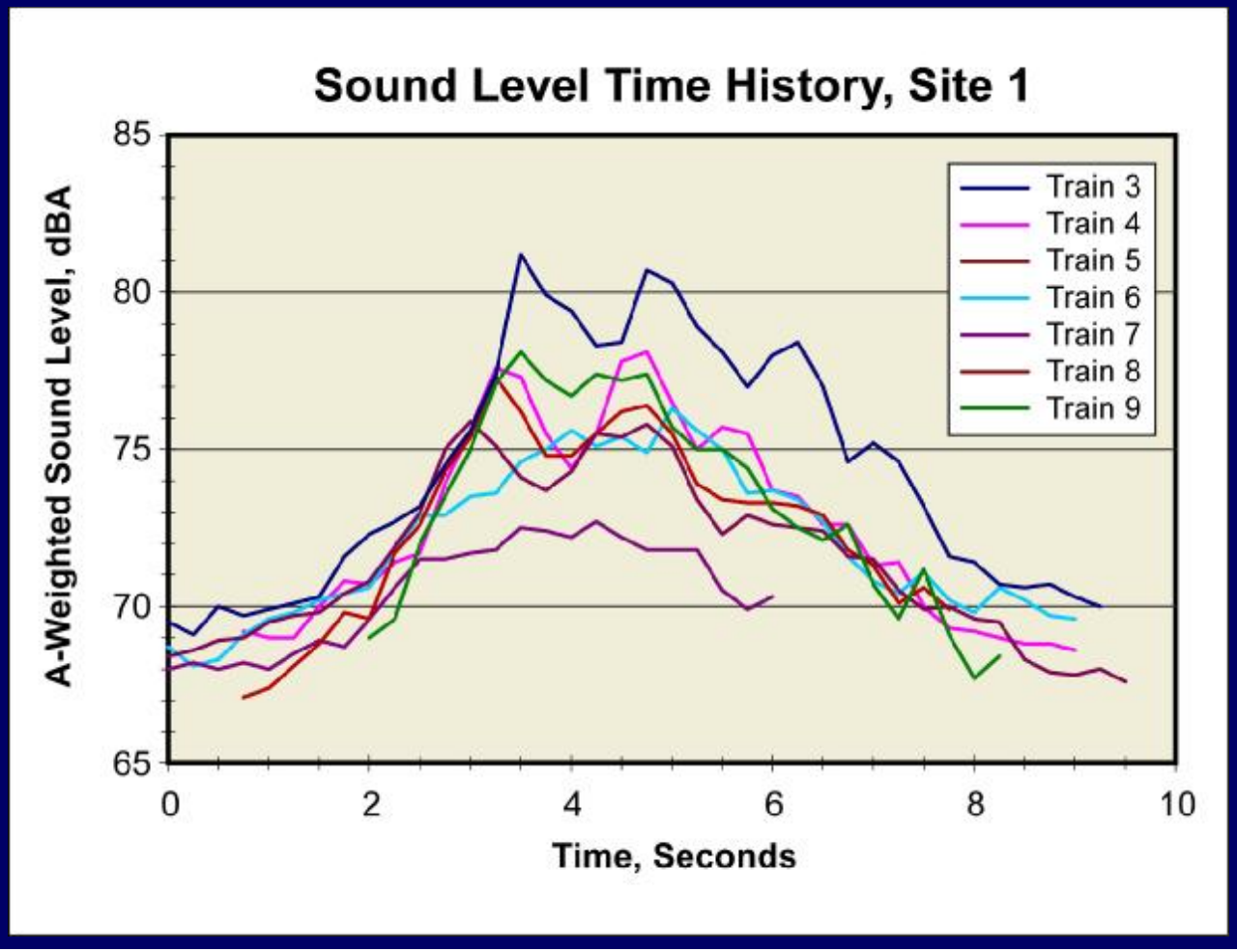
Portland Streetcar Test Sites



Portland Streetcar Test Sites



Test Results, Noise



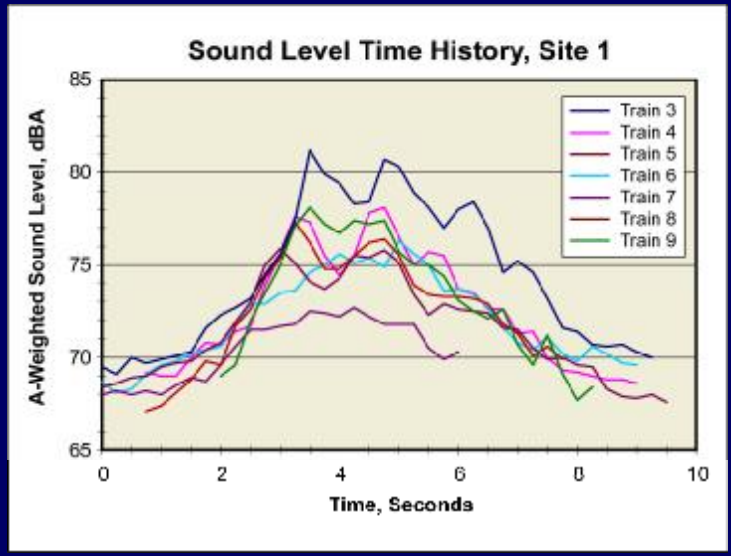
Test Results, Noise Time History

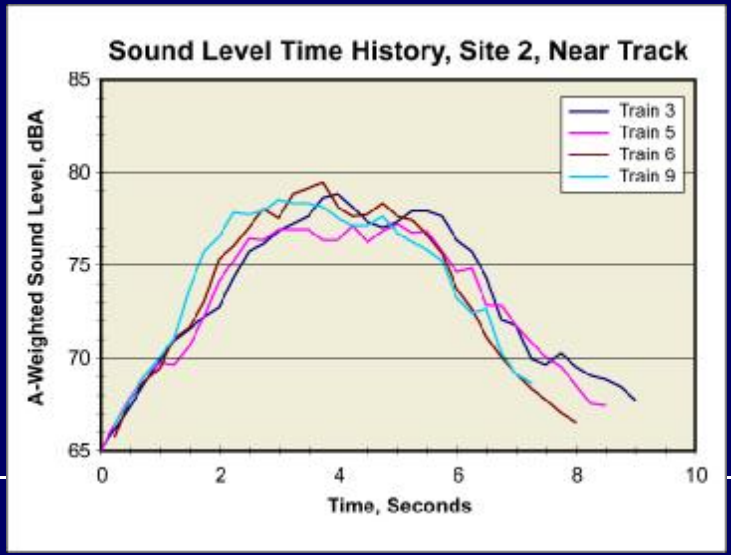
Average Leqs*

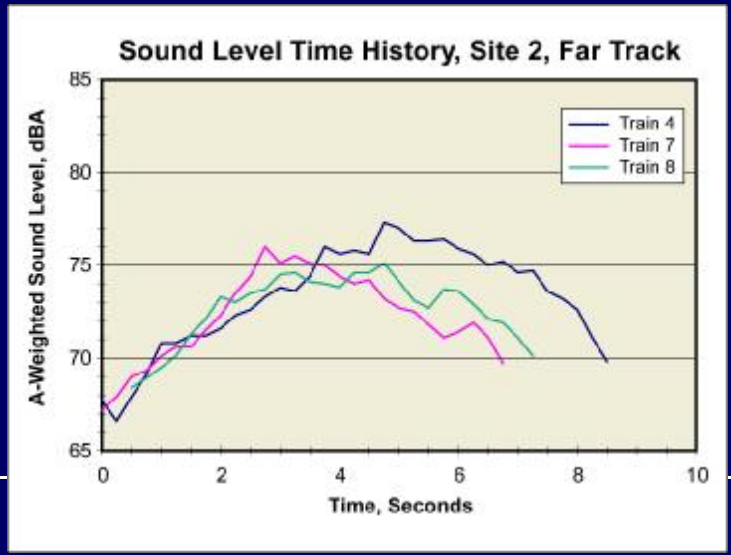
Site 1 (20 mph): 76.7 dBA

Site 2:
Near (20 mph) 77.6 dBA
Far (16 mph) 75.2 dBA

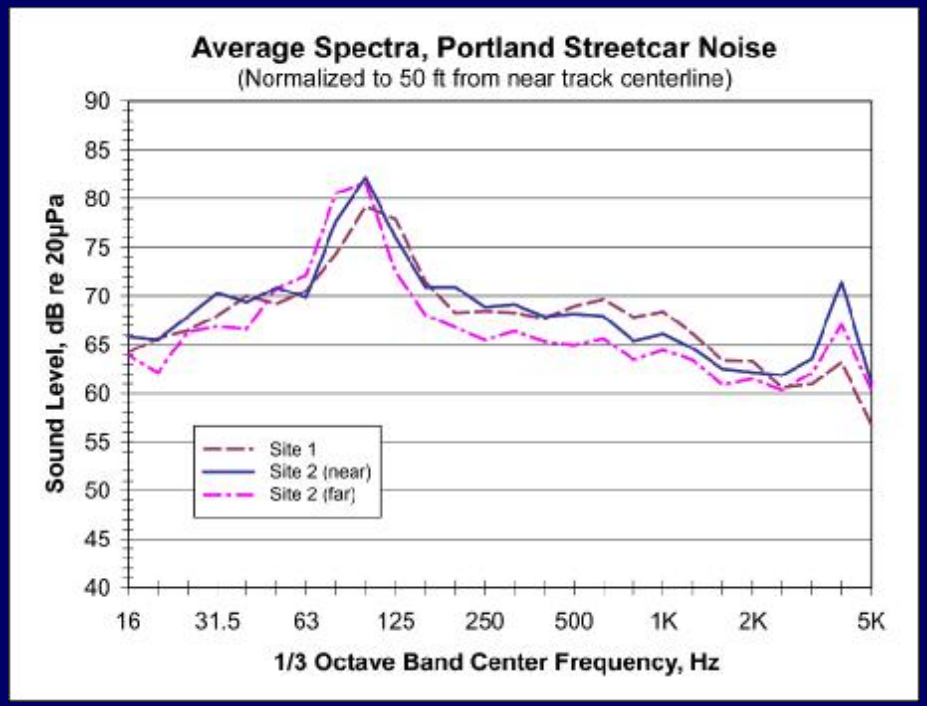
*averaged over passby time
Site 1: 50 ft, Site 2: 50 ft near track and 60 ft far track

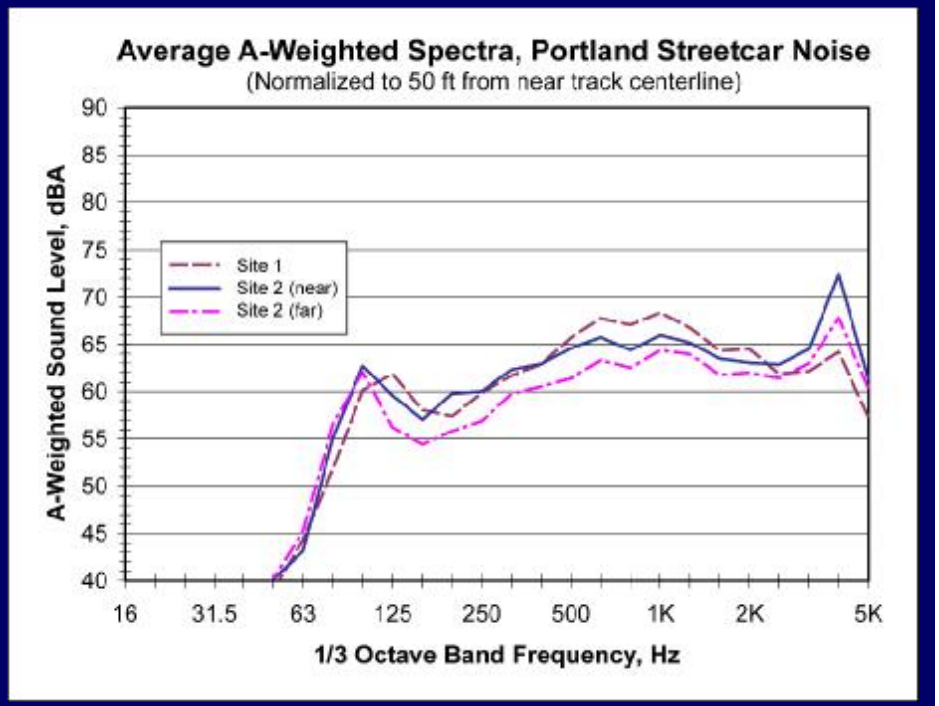




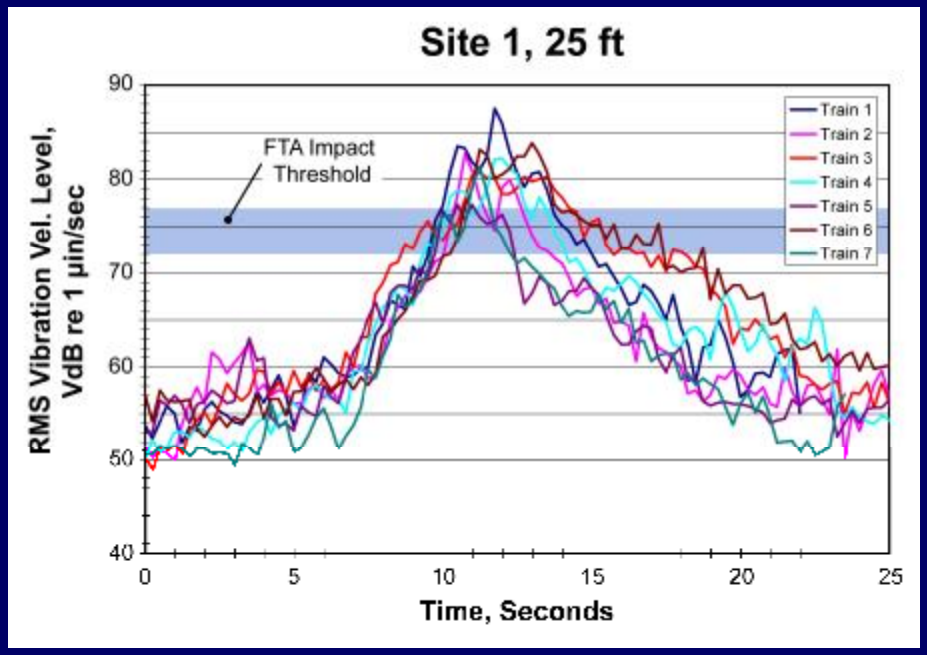


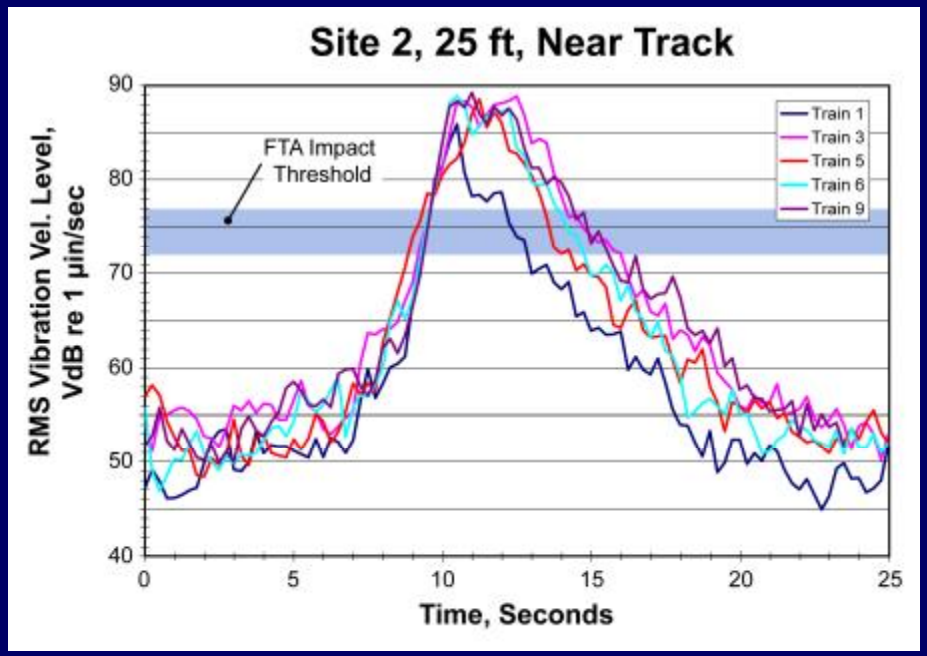
Test Results, Noise Spectrum



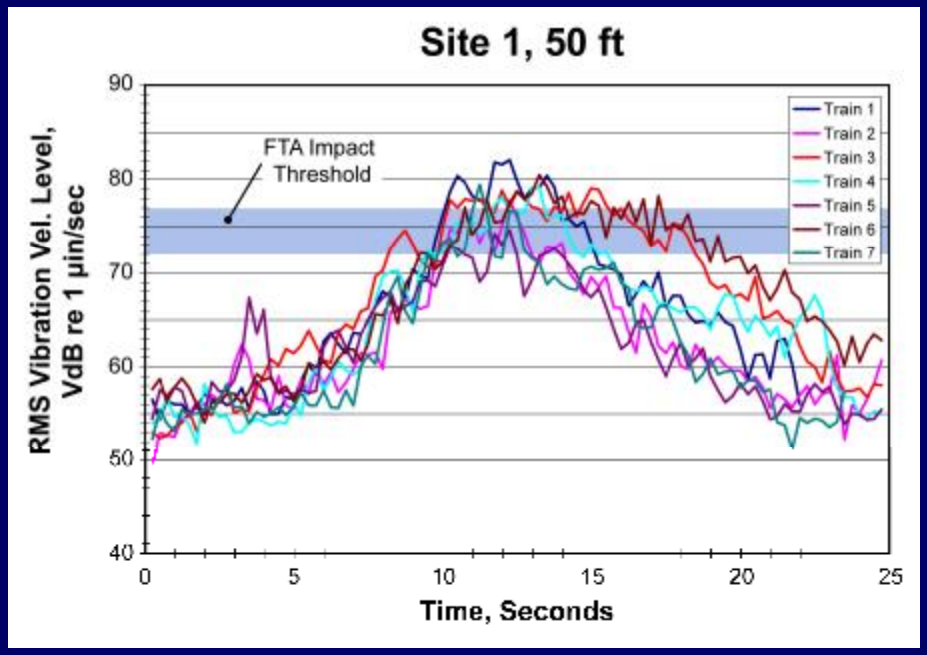


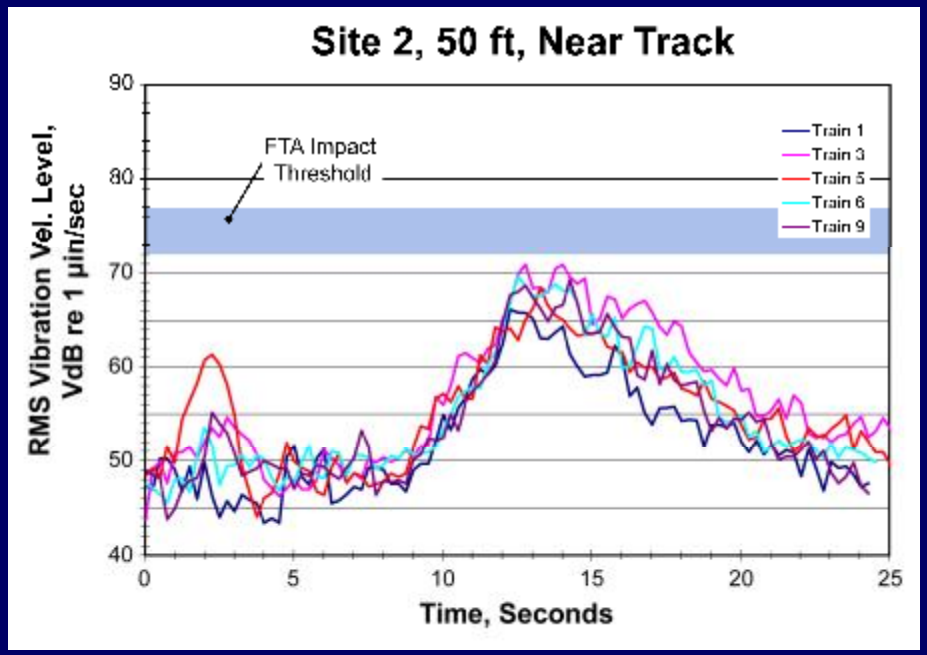
Test Results, Vibration at 25 ft



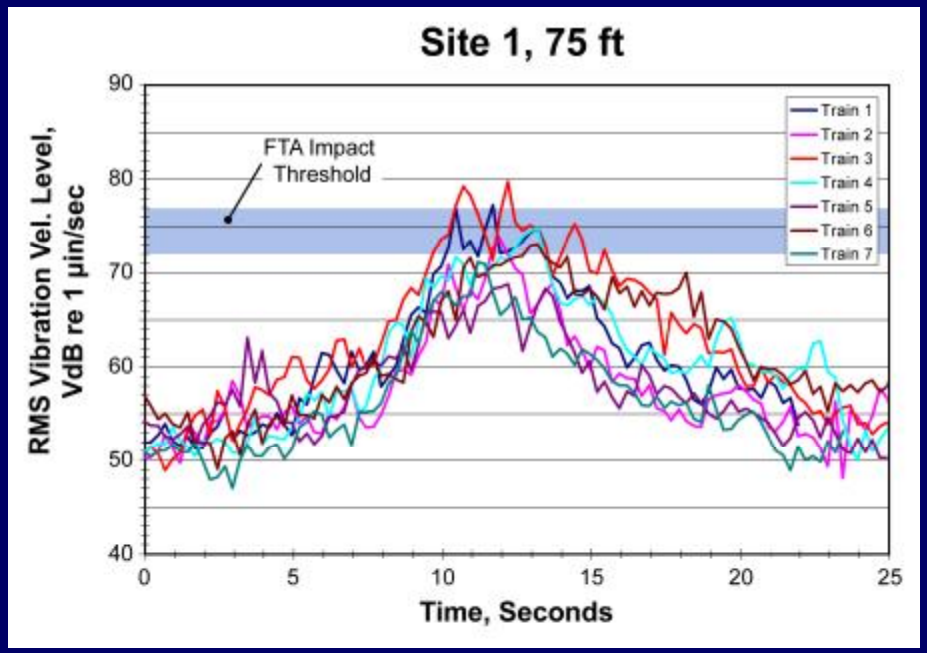


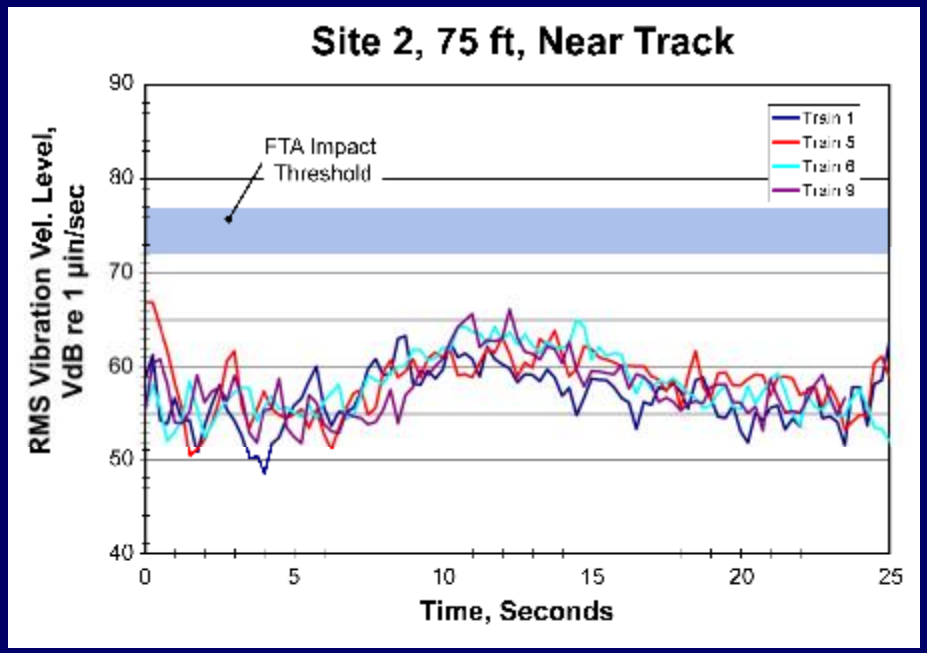
Test Results, Vibration at 50 ft



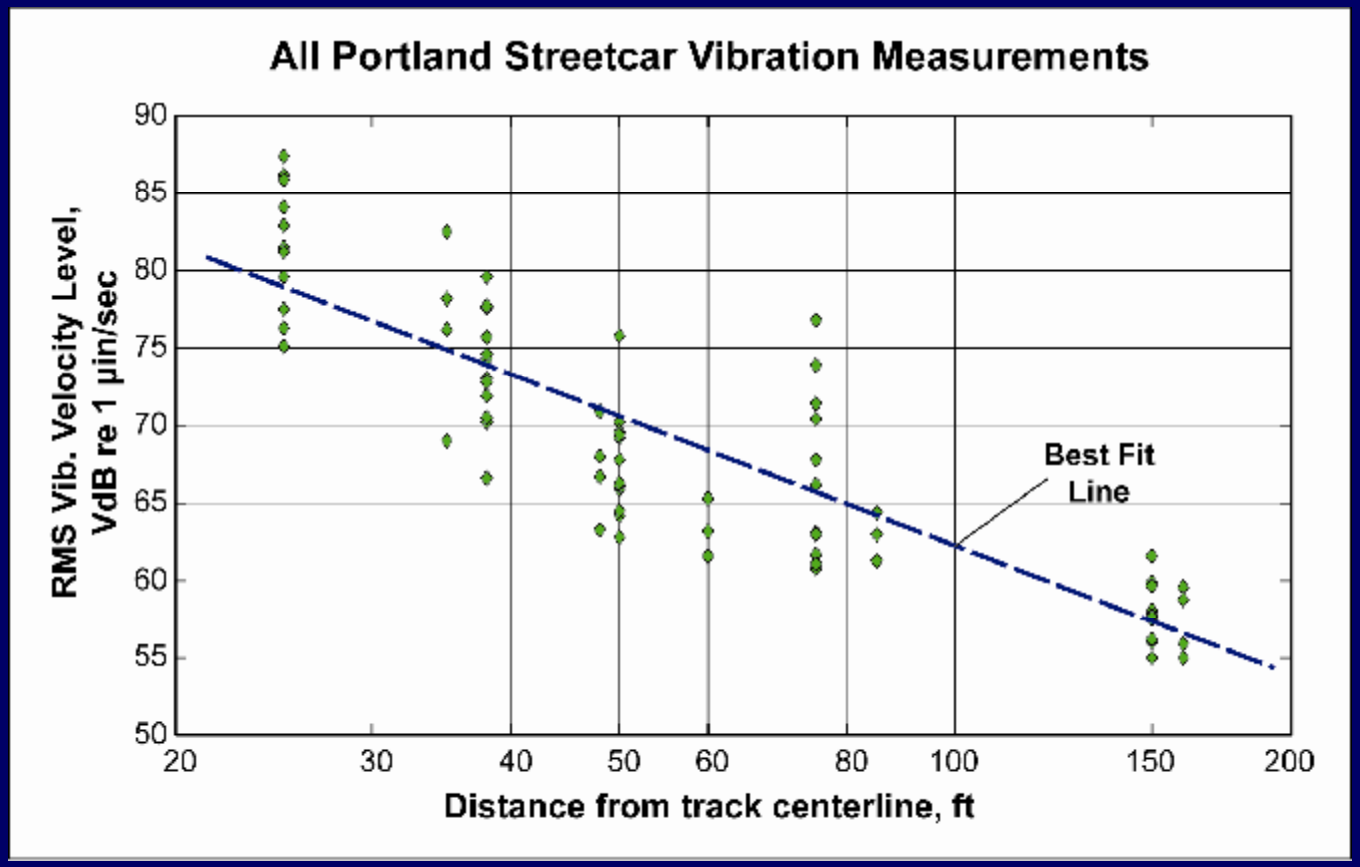


Test Results, Vibration at 50 ft

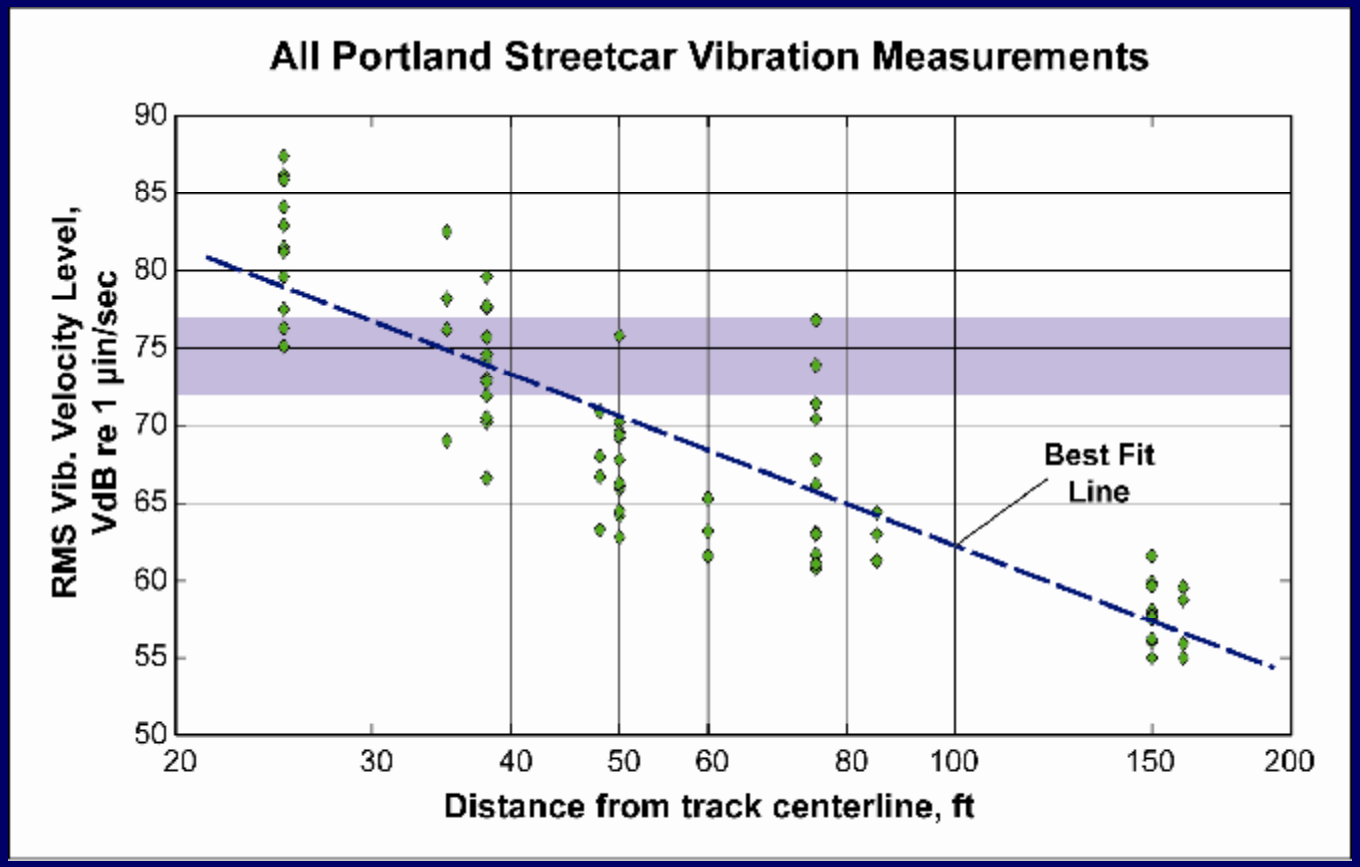




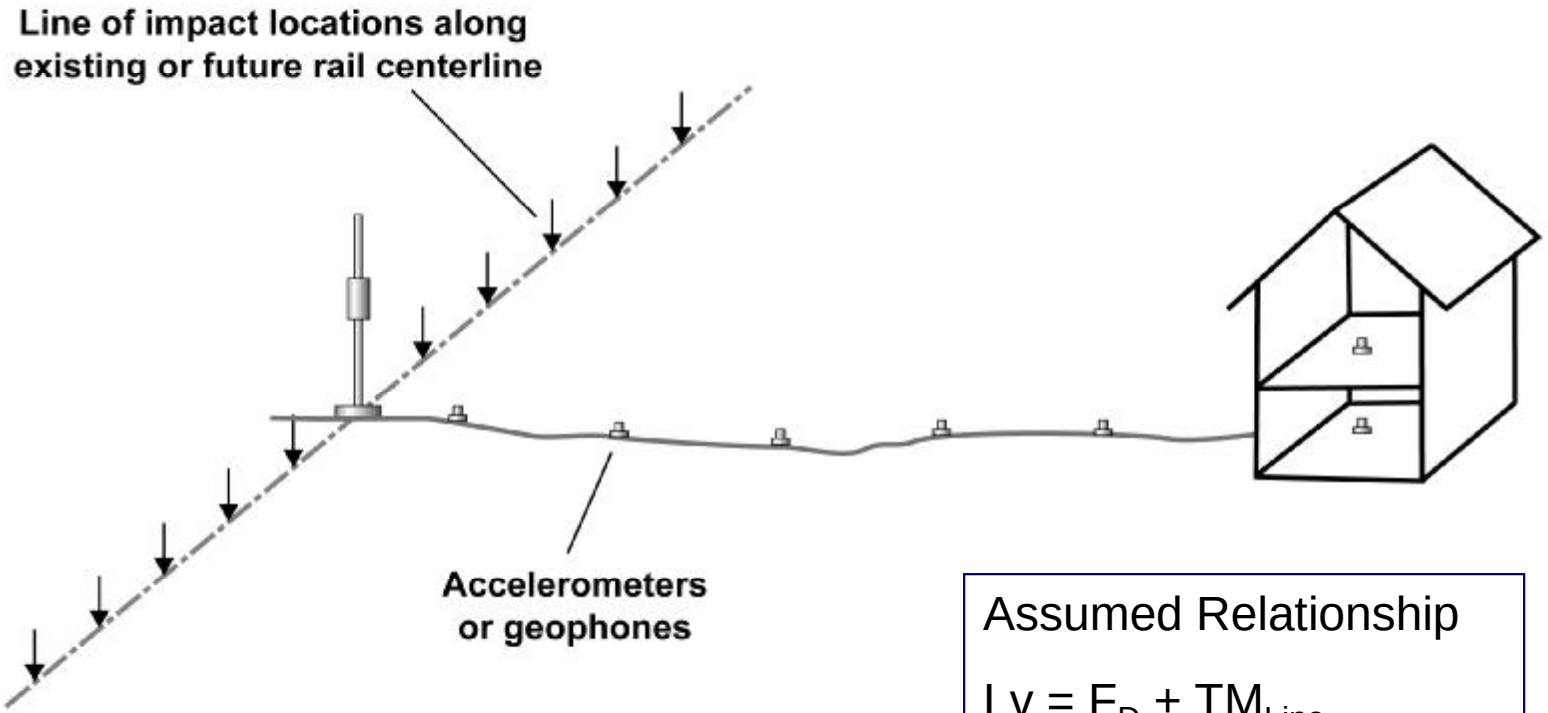
Overall Vibration Levels



Overall Vibration Levels



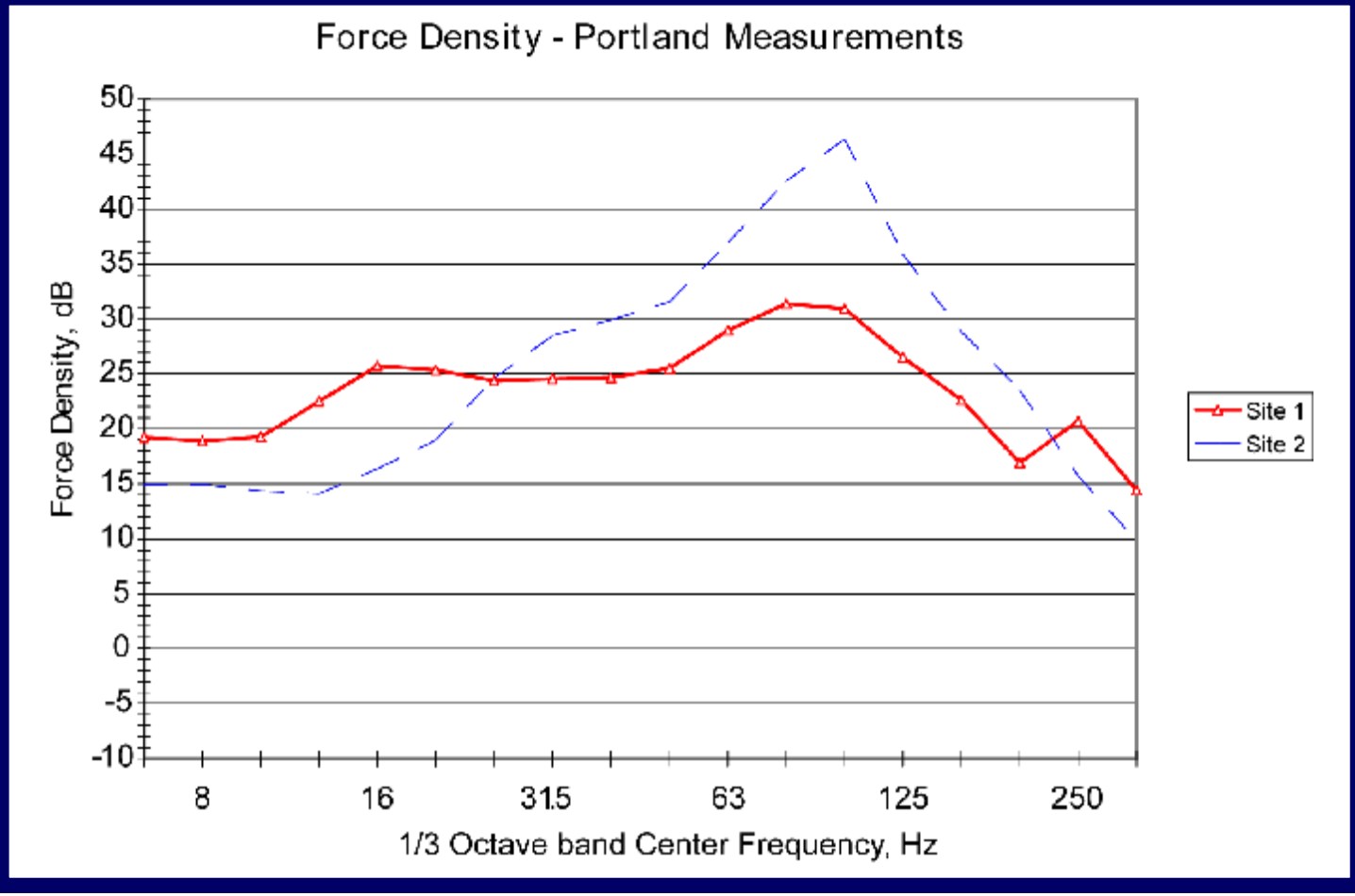
Vibration Propagation Test Procedure



Assumed Relationship

$Lv = F_D + TM_{Line}$

Derived Streetcar Force Densities



Vibration Predictions, Indoor