Noise, Vibration and EMI from Modern Streetcars

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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
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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

Average Spectra, Portland Streetcar Noise
(Normalized to 50 ft from near track centerline)

Average A-Weighted Spectra, Portland Streetcar Noise
(Normalized to 50 ft from near track centerline)
Test Results, Vibration at 25 ft

Site 1, 25 ft

Site 2, 25 ft, Near Track
Test Results, Vibration at 50 ft

**Site 1, 50 ft**

**Site 2, 50 ft, Near Track**

FTA Impact Threshold
Test Results, Vibration at 50 ft

**Site 1, 75 ft**

**Site 2, 75 ft, Near Track**

![Graphs showing vibration levels at different sites and times](image-url)
Overall Vibration Levels

All Portland Streetcar Vibration Measurements

- RMS Vib. Velocity Level, VdB re 1 μm/sec
- Distance from track centerline, ft

Best Fit Line
Overall Vibration Levels

All Portland Streetcar Vibration Measurements

RMS Vib. Velocity Level, VdB re 1 μm/sec

Distance from track centerline, ft
Vibration Propagation Test Procedure

Assumed Relationship

$L_v = F_D + T M_{\text{Line}}$

Line of impact locations along existing or future rail centerline

Accelerometers or geophones
Derived Streetcar Force Densities
Vibration Predictions, Indoor

Predicted Vibration Levels Inside Harshbarger Labs
("worst case" force density)

RMS Vib. Velocity Level, VdB re 1μin/sec

1/3 Octave band Center Frequency, Hz

- Lab6D
- Lab6C
- Lab6Dpad
- 150 ft (Jul)