Noise and Vibration Measurements for the DCTA Stadler DMU

TRB ADC40 Transportation-Related Noise and Vibration 2013 Summer Meeting

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INTRODUCTION

- A noise and vibration test program was conducted for the Stadler Model GTW 2/6 Diesel Multiple Unit (DMU) diesel-electric articulated rail vehicle.
- The DMU vehicles operate on the Denton County Transportation Authority (DCTA) A-Train system.
- The test program was conducted in Lewisville, Texas during December of 2012.
- The objective was to document wayside noise and ground-borne vibration levels from the DMU for application to projects with plans to use similar vehicles (e.g. DART Cotton Belt and FWTA TEX Rail).

DCTA Stadler DMU Test Train

Fully-equipped Stadler GTW 2/6 consisting of two 134-ft. long articulated vehicles weighing 161,500 lb. ea. (AW0)

Noise Measurement Methodology

- **Measurement Microphones –** located at 50 ft. and 100 ft. from the test track center line
- **Constant Speed Tests –** runs in each direction at constant speeds of 15, 30, 45 and 60 mph
- **Acceleration Tests –** runs in each direction accelerating at full throttle from 0 to 30 mph
- **Deceleration Tests –** runs decelerating from 30 to 0 mph, simulating a normal station stop
- **Stationary Tests –** tests of stationary vehicles at low and high idle speeds

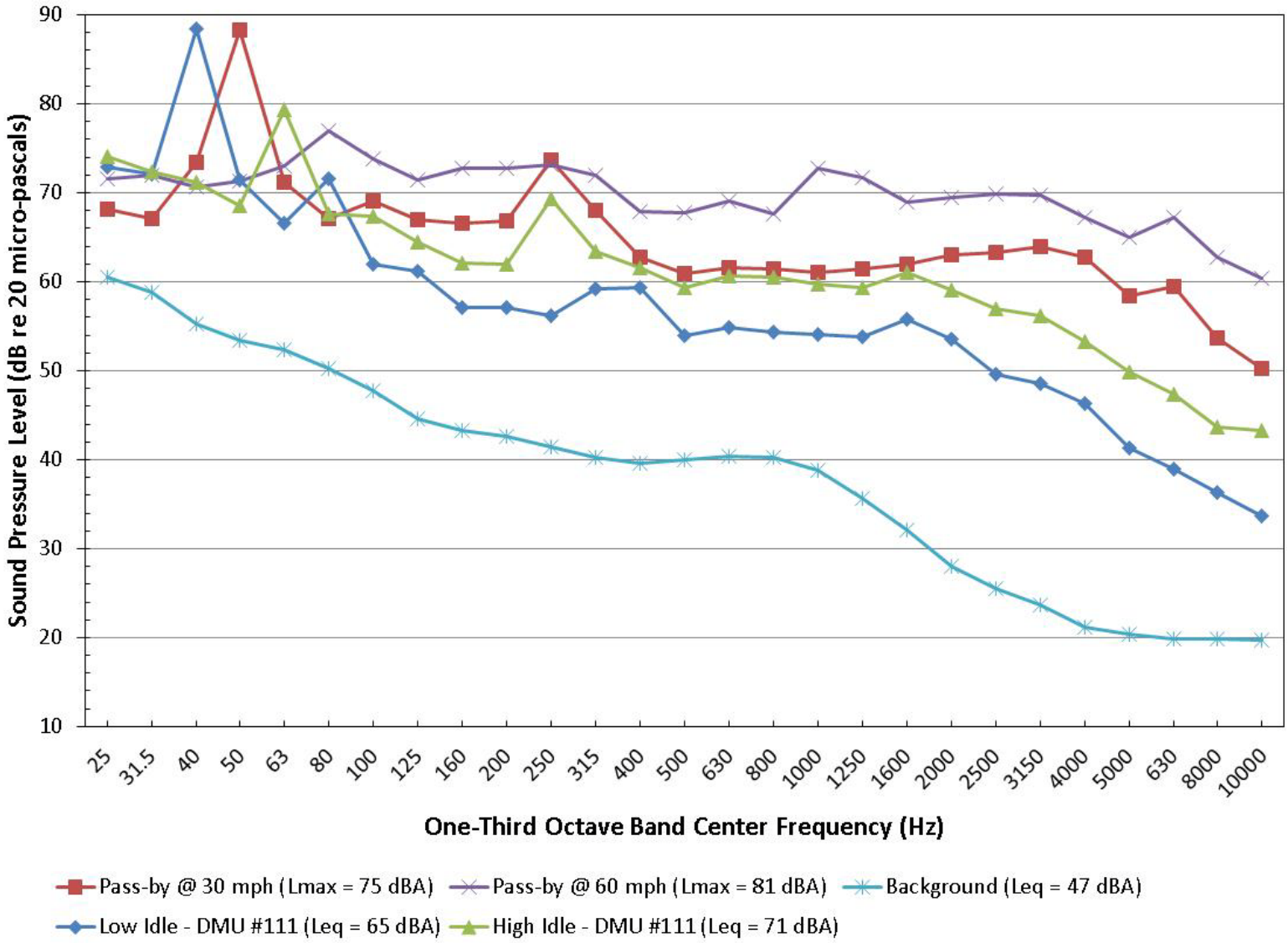
Noise and Vibration Test Location

A-Weighted Noise Measurement Results

Measurement Condition	Speed (mph)	Sound Level at 50 feet[1] (dBA)	SEL at 50 feet (dBA)	
			2-Car Train	Single Vehicle
Constant Speed Test	15	69	79	76
Constant Speed Test	30	75	82	79
Constant Speed Test	45	79	84	81
Constant Speed Test	60	81	86	83
Acceleration Test	0-30	80	87	84
Deceleration Test	30-0	76	84	81
Low Idle (Vehicle #111)	0	65	--	--
High Idle (Vehicle #111)	0	71	--	--
Background Noise Test	--	47	--	--

[1] Values for moving trains correspond to the maximum one-second Leq

DMU Noise Level Frequency Spectra (at 50 feet from the test track center line)



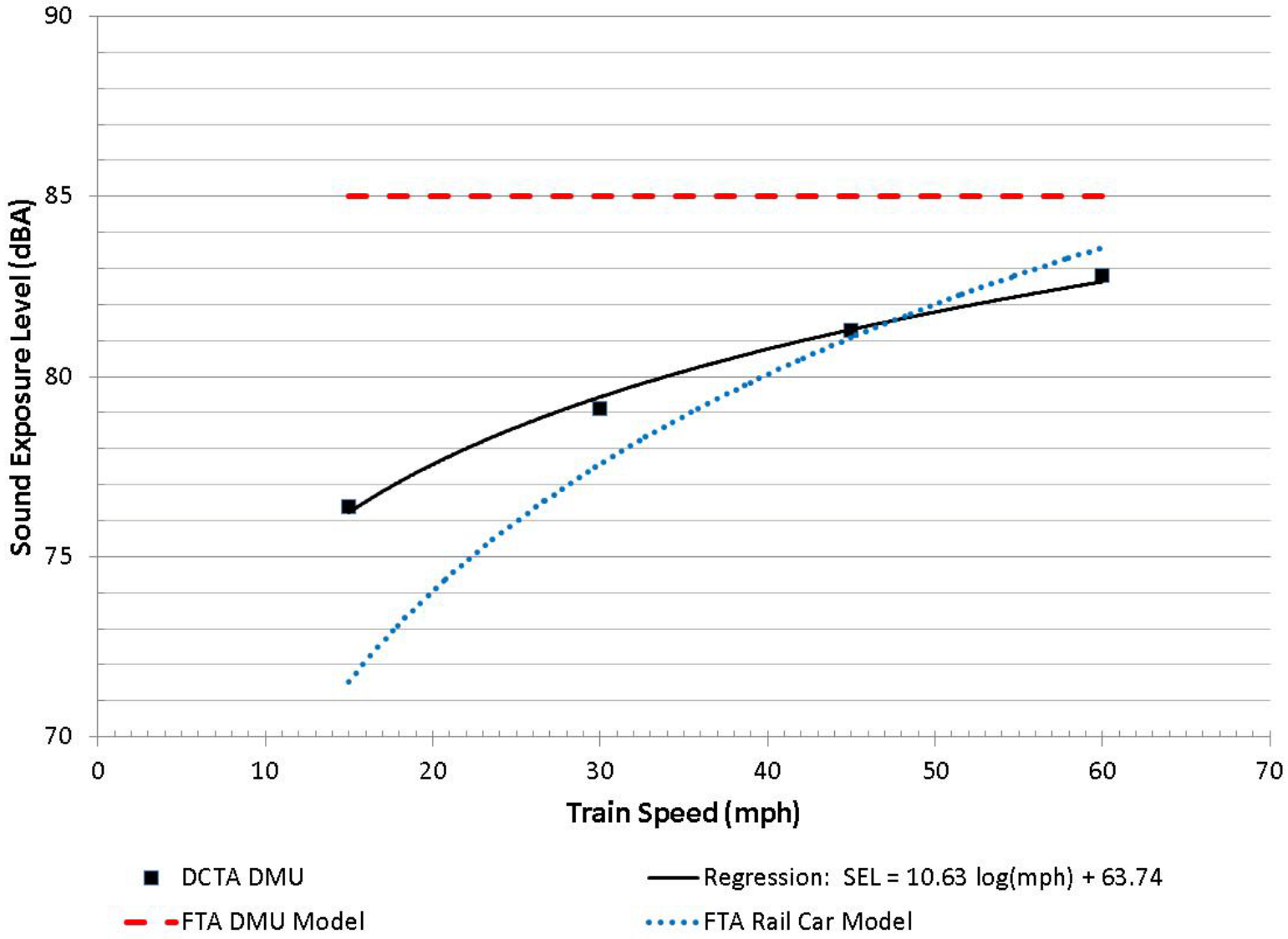
Noise Measurement Observations

- Constant speed tests indicate that one-third octave band noise levels typically increase with increasing speed above 63 Hz
- Spectra at lower speeds include peak at 50 Hz generated by the diesel engines
- Stationary low-idle condition includes peak at 40 Hz
- Peak shifts to 63 Hz for high-idle condition
- Potential for annoyance from noise-induced vibration if DMU vehicles idle in close proximity to residences

DMU Noise Prediction Model

- The FTA guidance manual has a method for predicting noise from DMU vehicles (although measurements are preferred).
- The FTA method is based on older DMU technology which may not be applicable to the newer Stadler vehicles used by DCTA.
- A primary objective of the DMU test program was to develop a model to predict noise from the Stadler vehicles for impact assessments on other projects.
- The noise prediction model is based on the Sound Exposure Level (SEL) for a single-vehicle pass-by.

Sound Exposure Level (SEL) vs. Speed (at 50 feet)



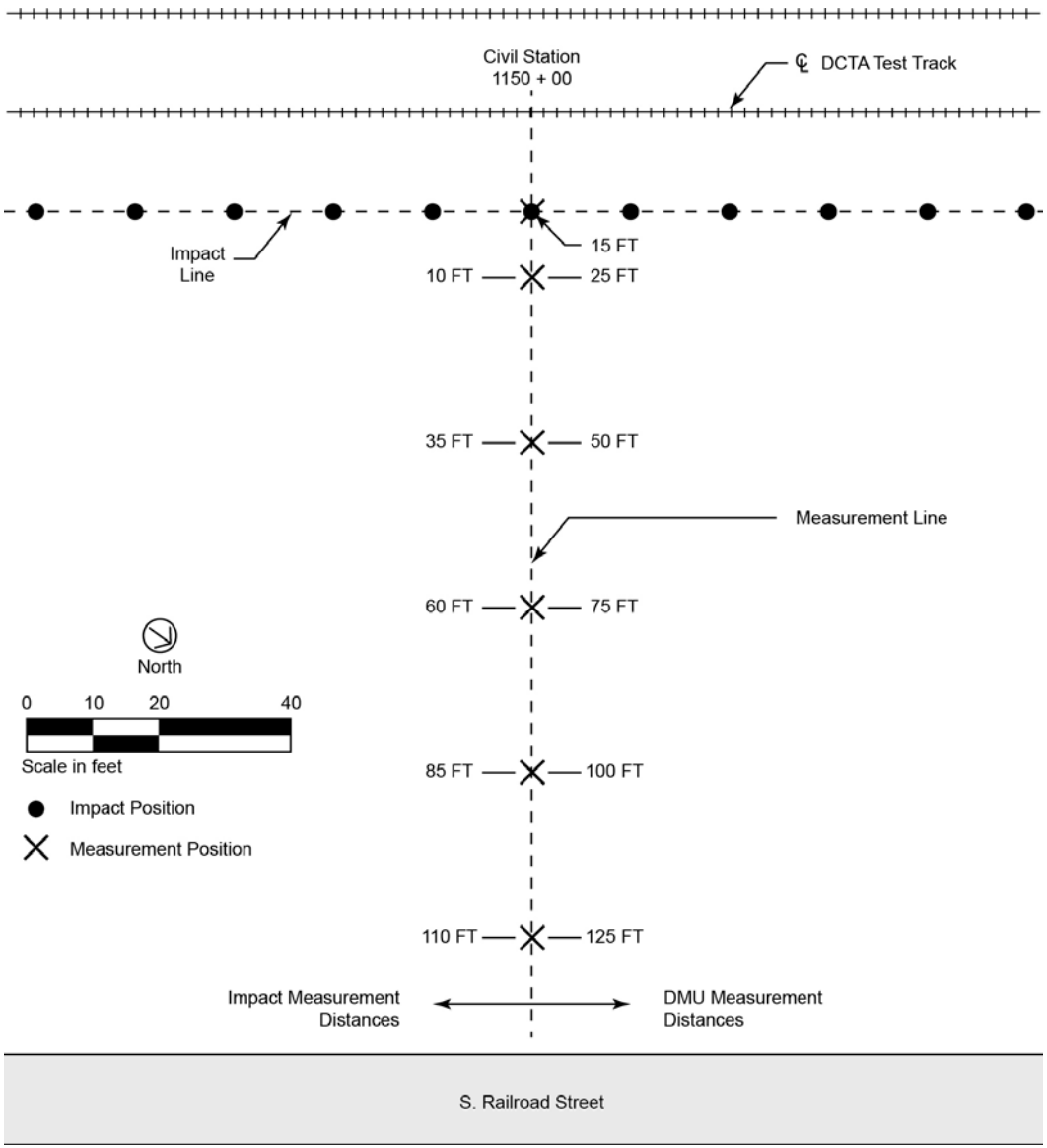
DMU Noise Prediction Model: SEL

- **FTA Prediction Models:**
  - SEL for DMU is independent of speed
  - SEL for rail cars varies in proportion to 20*Log(Speed)
- **Stadler DMU:**
  - SEL < FTA DMU model below 60 mph
  - SEL > FTA rail car model below 45 mph
  - SEL (at 50 ft.) = 10.63*Log(mph) + 63.74
  - Adjustments made for added noise from operation at higher throttle settings and from regenerative braking

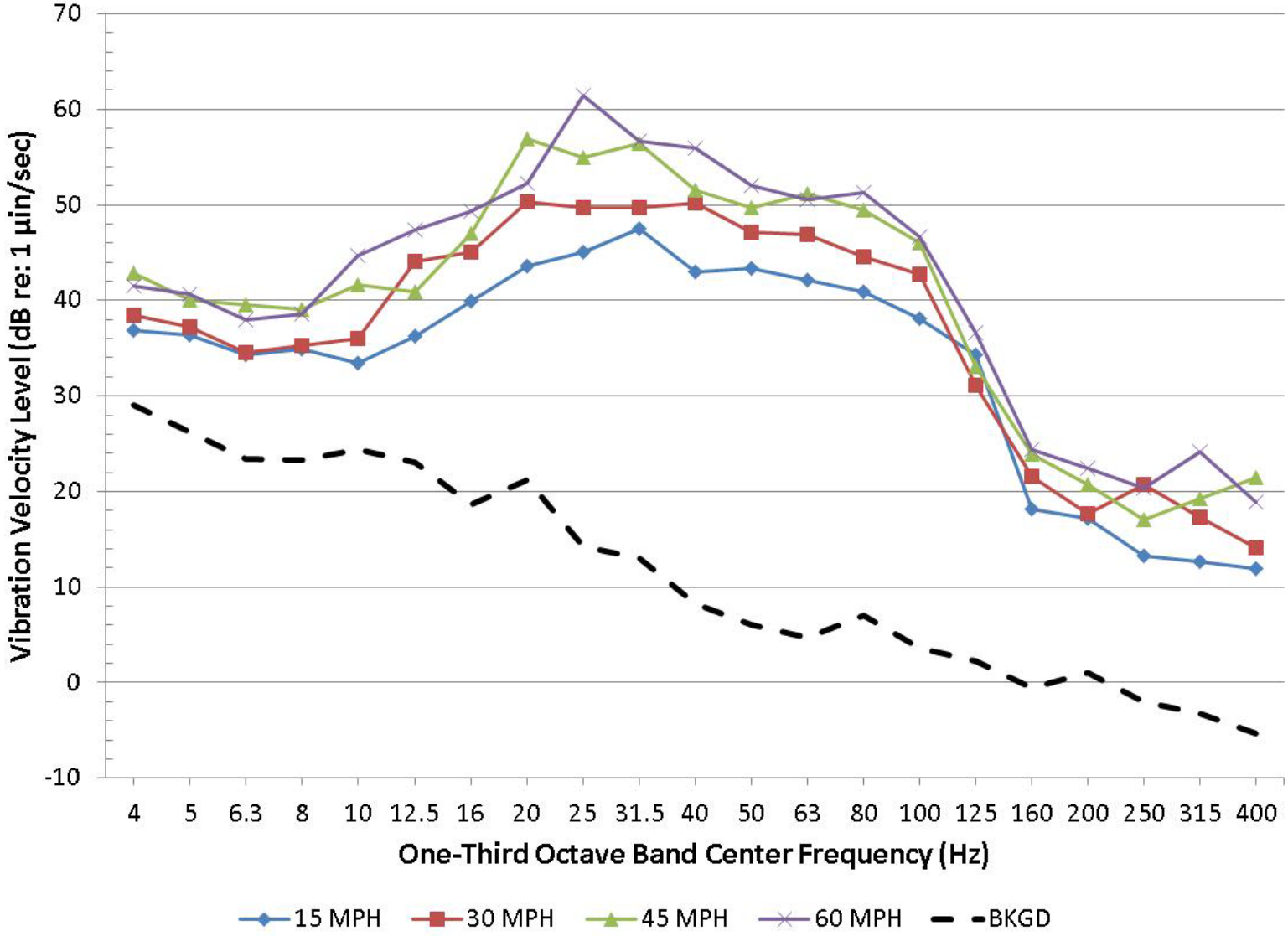
Vibration Test Procedures

- **DMU Ground Vibration Measurements:**
  - Runs of the DMU test train were made in each direction at constant speeds of 15, 30, 45 and 60 mph.
  - Vertical ground vibration was measured at 6 positions, with accelerometers at distances ranging between 15 and 125 feet from the test track center line.
- **Ground Vibration Propagation Tests:**
  - Impact forces were generated at 11 points spaced 15 feet apart along a line parallel to and 15 feet from the track.
  - Vibration response was measured at 5 positions on the ground ranging from 10 to 110 feet from the impact line.
  - The relationship between the impact force and ground surface vibration determines the line source transfer mobility (LSTM).

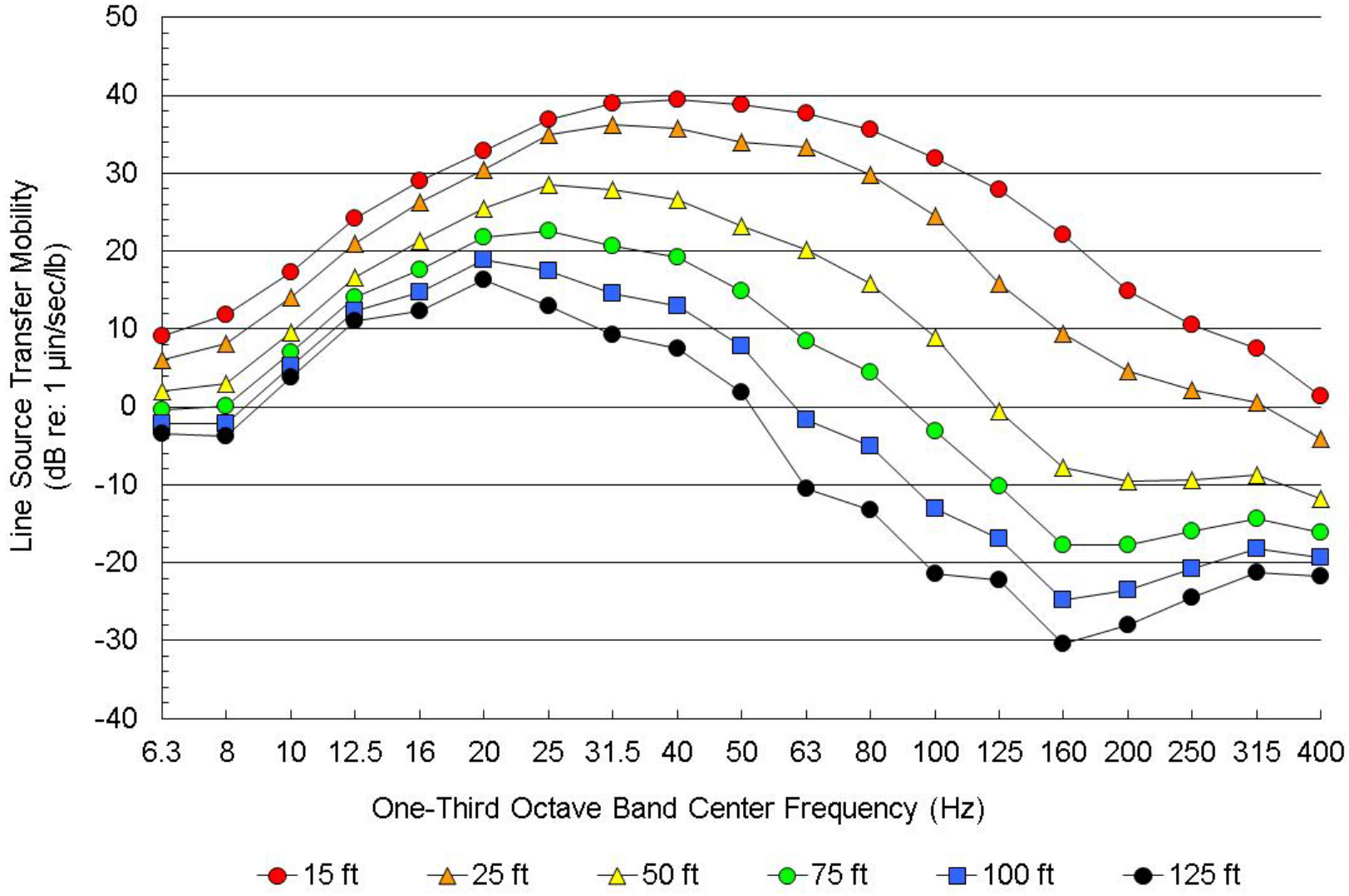
Ground-Borne Vibration Test Locations



Average DMU Ground Vibration Level Spectra vs. Speed (at 50 feet from the track center line)



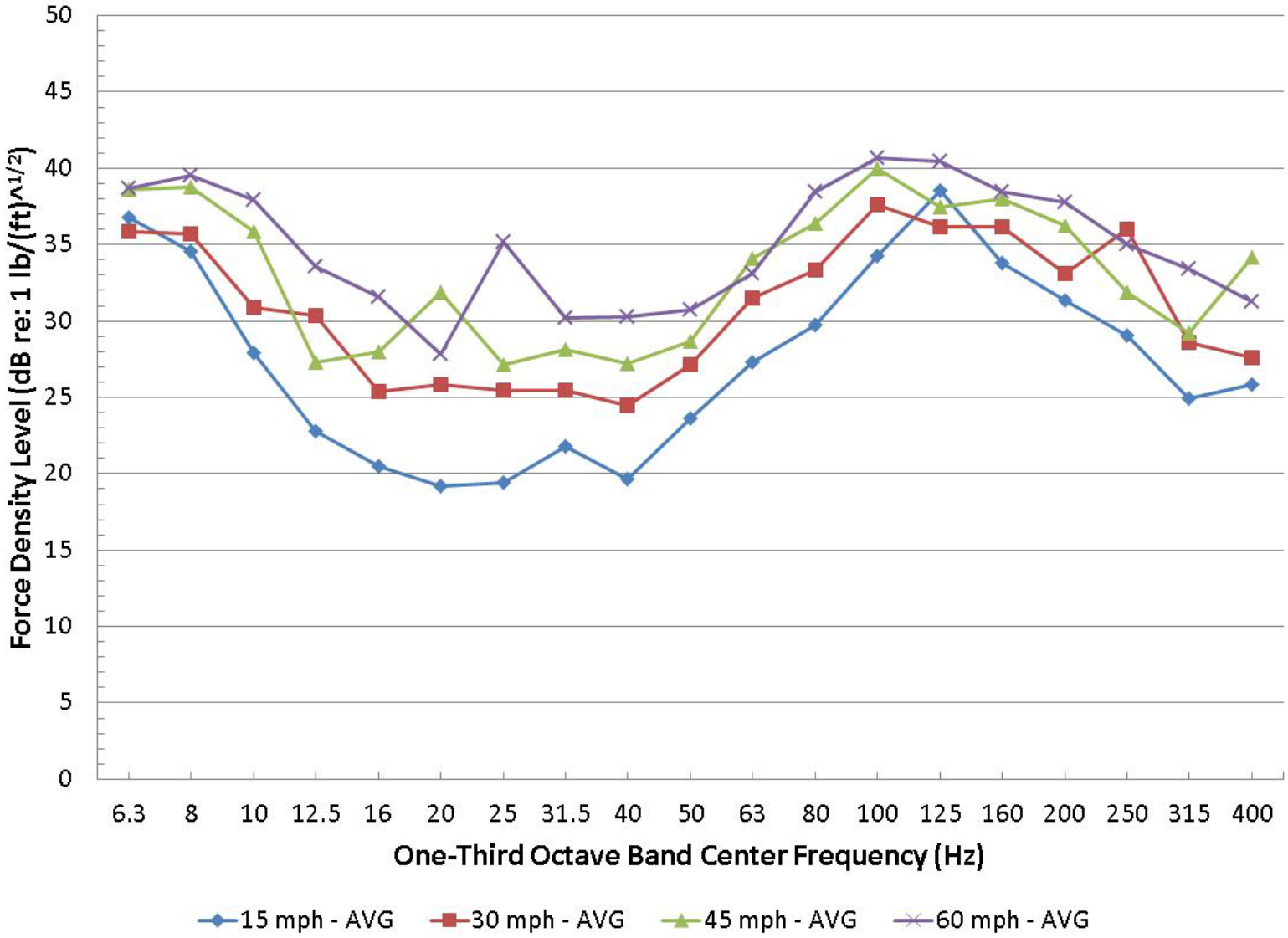
Line Source Transfer Mobilities (LSTM) at Test Site



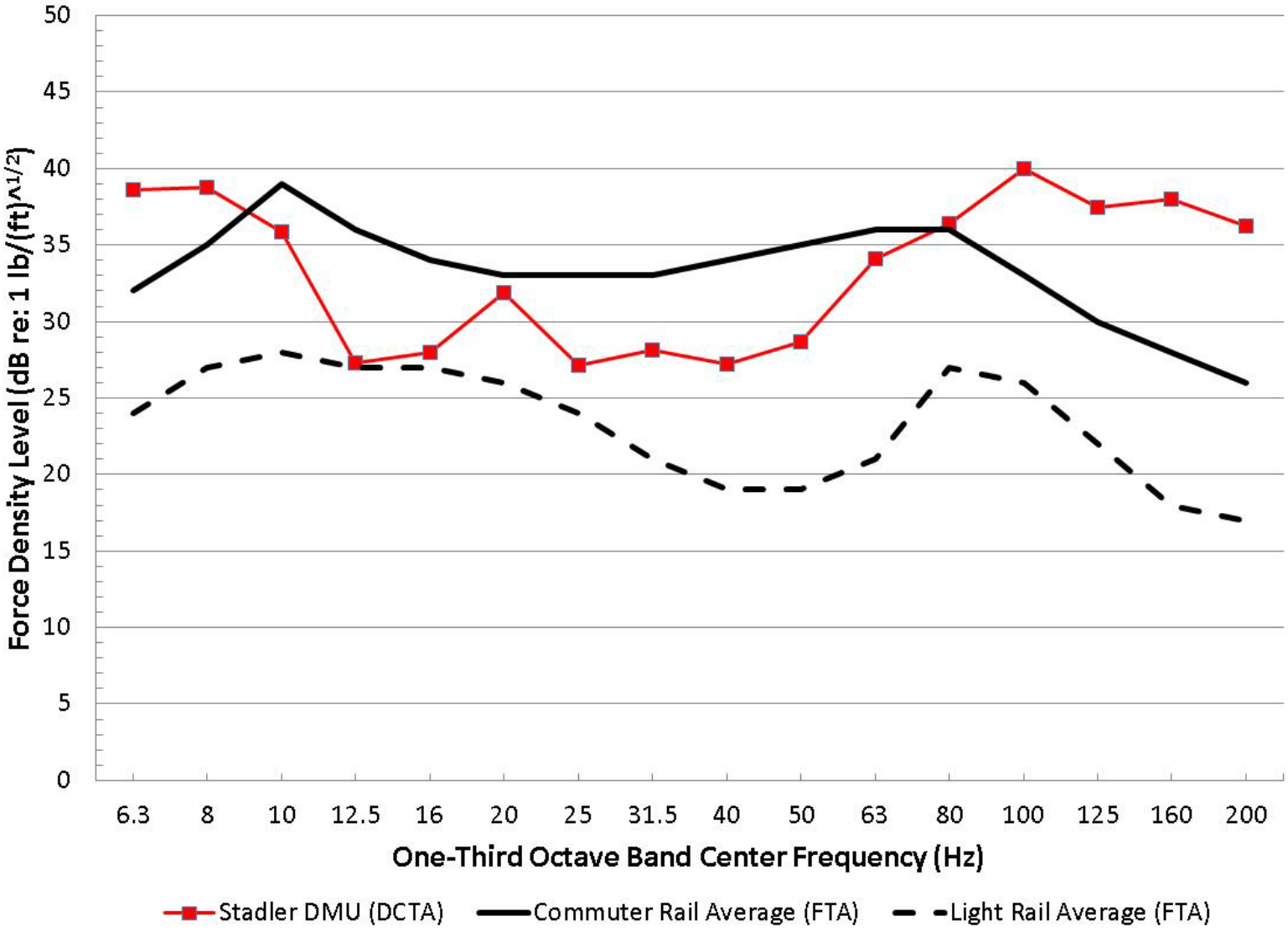
DMU Vibration Prediction Model: Force Density Level

- **FTA detailed vibration analysis prediction method is based on the Force Density Level (FDL)**
- **FDL spectra are calculated for specific DMU speeds**
- **FDL = Lv – LSTM**
  - Lv = rms ground vibration velocity level
  - LSTM = line source transfer mobility

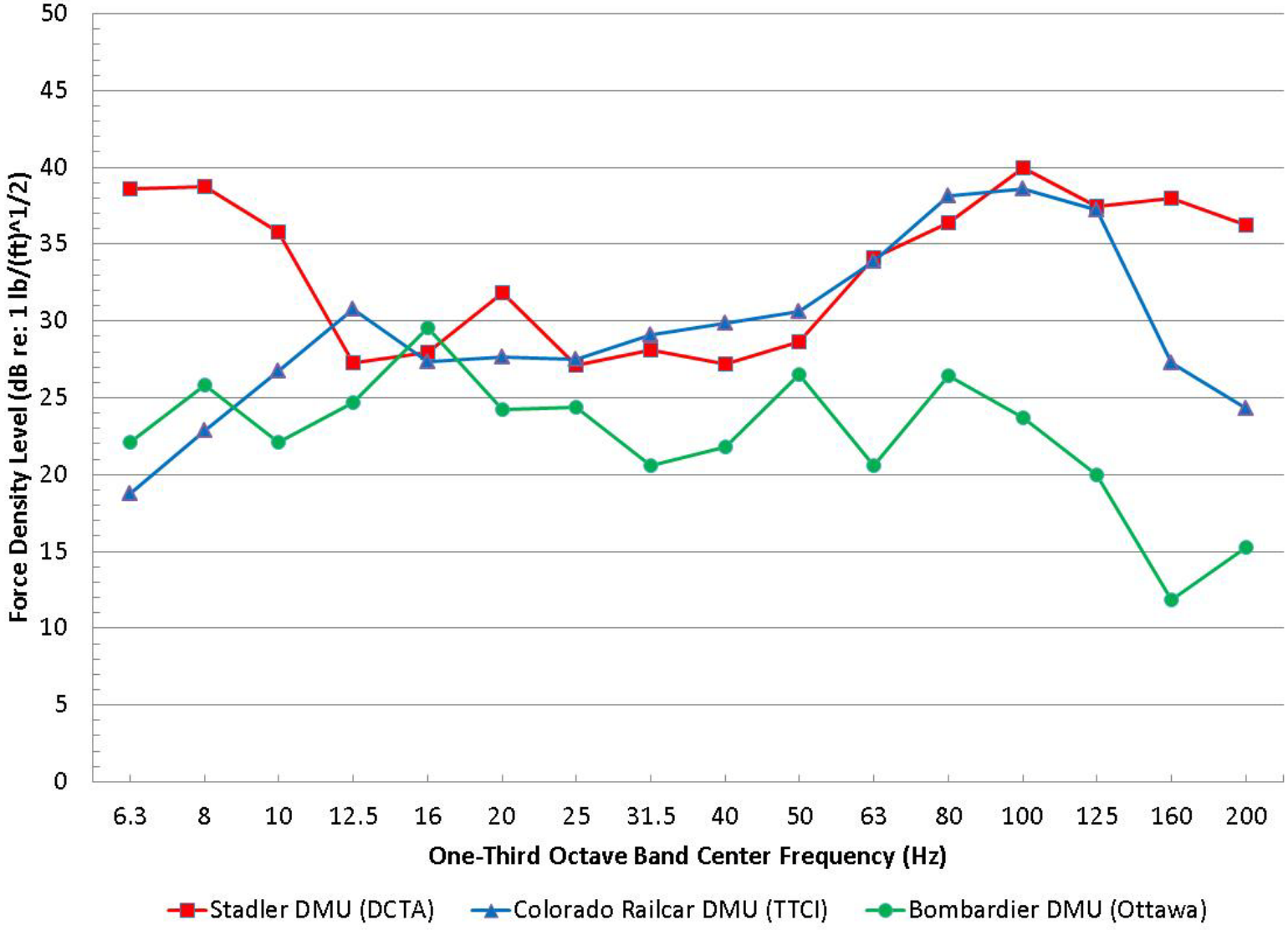
DMU Force Density Levels vs. Speed



Comparison of DCTA Stadler DMU Force Density Levels with FTA Averages (at 45 mph)



Comparison of Force Density Levels for Different DMU Vehicles (at 45 mph)



Summary of DMU Force Density Level Comparisons

- DCTA Stadler DMU FDL values fall in between the FTA average values for commuter and light rail vehicles in the 10 Hz to 80 Hz frequency range

- DCTA Stadler DMU FDL values are similar to Colorado Railcar DMU values between 12.5 Hz and 125 Hz

- DCTA Stadler DMU FDL values are generally higher than those for the Bombardier Ottawa DMU

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Thank You!

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