

Overview of Measured Effects of Mitigation for LRT Systems

Shannon McKenna
ATS Consulting
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Presentation Outline

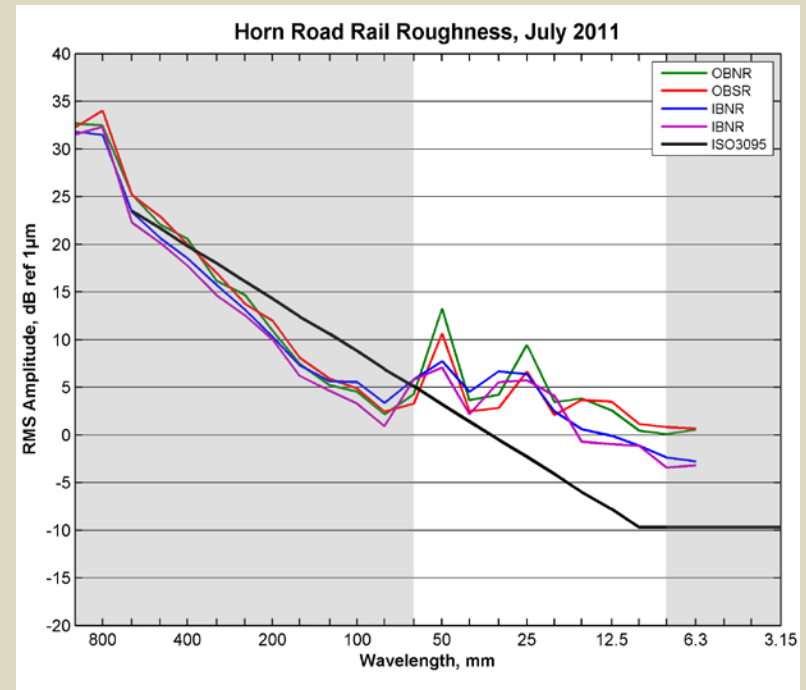
- FTA guidance on noise and vibration mitigation reduction
- Noise mitigation options:
 - Rail grinding
 - Rail dampers
 - Low-impact frogs
- Vibration mitigation options
 - Resilient fasteners
 - Ballast mat
 - Tire-derived aggregate
 - Floating slab track

FTA Guidance: Noise Mitigation

Table 6-12. Transit Noise Mitigation Measures		
Application	Mitigation Measure	Effectiveness
SOURCE	Stringent Vehicle & Equipment Noise Specifications	Varied
	Operational Restrictions	Varied
	Resilient or Damped Wheels*	For Rolling Noise on Tangent Track: 2 dB
		For Wheel Squeal on Curved Track: 10-20 dB
	Vehicle Skirts*	6-10 dB
	Undercar Absorption*	5 dB
	Spin-slide control (prevents flats)*	**
	Wheel Truing (eliminates wheel flats)*	**
	Rail Grinding (eliminates corrugations)*	**
	Turn Radii greater than 1000 ft*	(Avoids Squeal)
	Rail Lubrication on Sharp Curves*	(Reduces Squeal)
	Movable-Point Frogs (reduce rail gaps at crossovers)*	(Reduces Impact Noise)
	Engine Compartment Treatments (Buses)	6-10 dB
PATH	Sound Barriers close to Vehicles	6-15 dB
	Sound Barriers at ROW Line	3-10 dB
	Alteration of Horiz. & Vert. Alignments	Varied
	Acquisition of Buffer Zones	Varied
	Ballast on At-Grade Guideway*	3 dB
	Ballast on Aerial Guideway*	5 dB
	Resilient Track Support on Aerial Guideway	Varied
RECEIVER	Acquisition of Property Rights for Construction of Sound Barriers	5-10 dB
	Building Noise Insulation	5-20 dB
<p>* Applies to rail projects only</p> <p>** These mitigation measures work to maintain a rail system in its as-new condition. Without incorporating them into the system, noise levels could increase up to 10 dB.</p>		

Rail Grinding

- Implementing a rail grinding program and enforcing a rail roughness specification may reduce noise levels
- Need to document rail roughness levels during reference noise measurements
- Rail grinding was accepted as a mitigation measure for the Sac RT South Line after a detailed rail grinding study was conducted.



Rail Grinding

Noise Reduction from Grinding in Sacramento:

Location	Difference, Nov 2012	Difference, Feb 2011	Difference, July 2011
Site 1, Mercantile	-2.4	0.0	-2.4
Site 2, Natoma	-5.9	-3.7	-5.1
Nov 2012 is immediately after grinding, Feb 2011 is three months after grinding, July 2011 is eight months after rail grinding and one week after wheel truing			

Noise Reduction from Grinding in Saint Louis:

Alignment Section	A-Wt 2010	630-1000 Hz 2010	A-Wt 2013	630-1000 Hz 2013	A-Wt Difference	630-1000 Hz Difference
Red Line EB (Lambert-Shiloh Scott)	79.0	78.3	74.4	67.7	-4.6	-10.6
Red Line WB (Shiloh Scott-Lambert 1)	79.5	79.2	73.9	67.6	-5.6	-11.6
Blue Line EB (Shrewsbury-Forest Park)	76.7	75.3	78.3	72.8	1.6	-2.5
Blue Line WB (Forest Park-Shrewsbury)	75.5	74.2	75.0	69.4	-0.4	-4.8

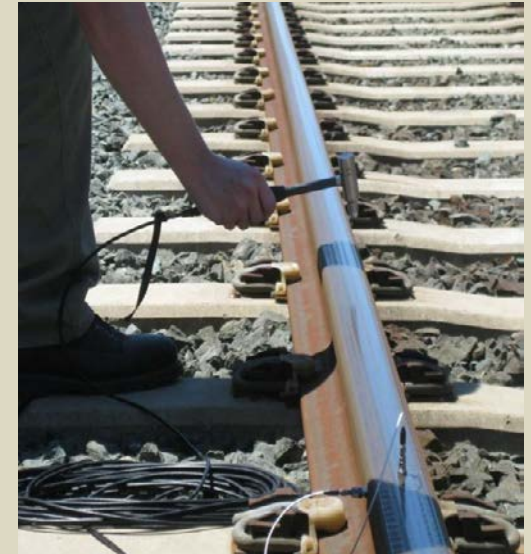
Rail Dampers

- Dampers are tuned to absorb specific vibration frequencies which reduces the amount of noise radiated by the rail.
- Dampers are attached to the rail. The figure shows two dampers installed between each tie.



Rail Dampers

- Measurements from test section at SacRT show reduction in wayside noise levels by 3 dB.
- Measurements of rail vibration with dampers show a decrease in vibration levels of up to 15 dB, indicating the dampers reduced noise radiated off of the rail to a level substantially lower than the noise radiated off of the wheels.
- Installing supplemental wheel dampers may further decrease the noise levels.
- Measurements at BART show installation of rail dampers is helping to slow corrugation growth.



What is a frog?

- The frog is the part of a turnout where two rails cross
- The gap in the rail creates a banging noise

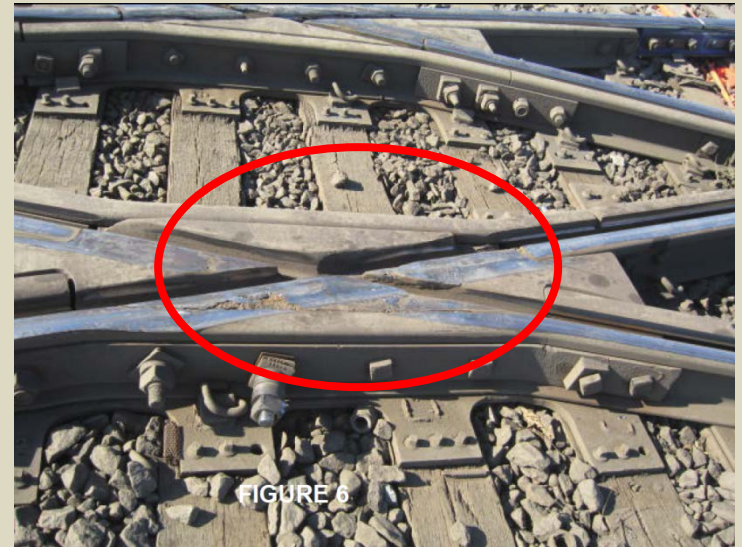
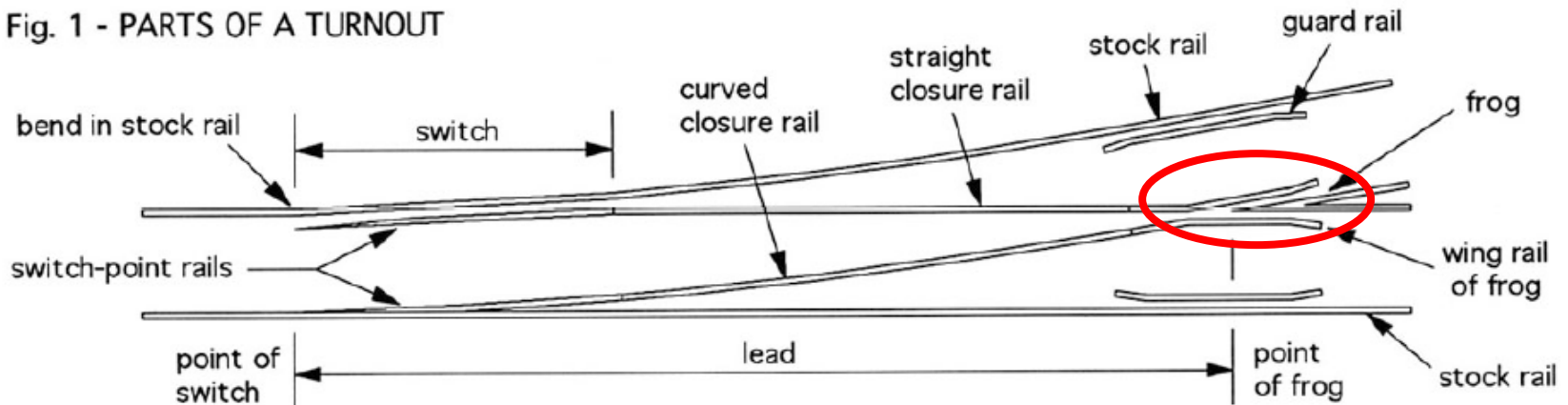


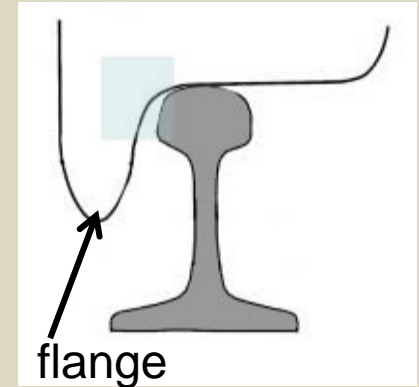
FIGURE 6

Fig. 1 - PARTS OF A TURNOUT



Low-Impact Frogs

- **Flange-bearing frogs**
 - The wheel will ride on the flange on a ramp through the gap providing a smoother transition.
 - May reduce noise and vibration levels by half.
- **One-way low speed (OWL frogs)**
 - Flange-bearing in diverting direction and no gap in the main line direction.
 - For emergency turnouts, could be little or no increase in noise and vibration.
- **Spring rail and moveable point frogs**
 - Have a moveable wing rail held against the point rail by springs.
 - Expensive and difficult to maintain, but result in only a marginal increase in noise and vibration.
- **Monoblock frogs**
 - Machined out of a single block of steel with tighter tolerances.
 - Preliminary measurements show may reduce noise and vibration levels by half.



Spring frog:

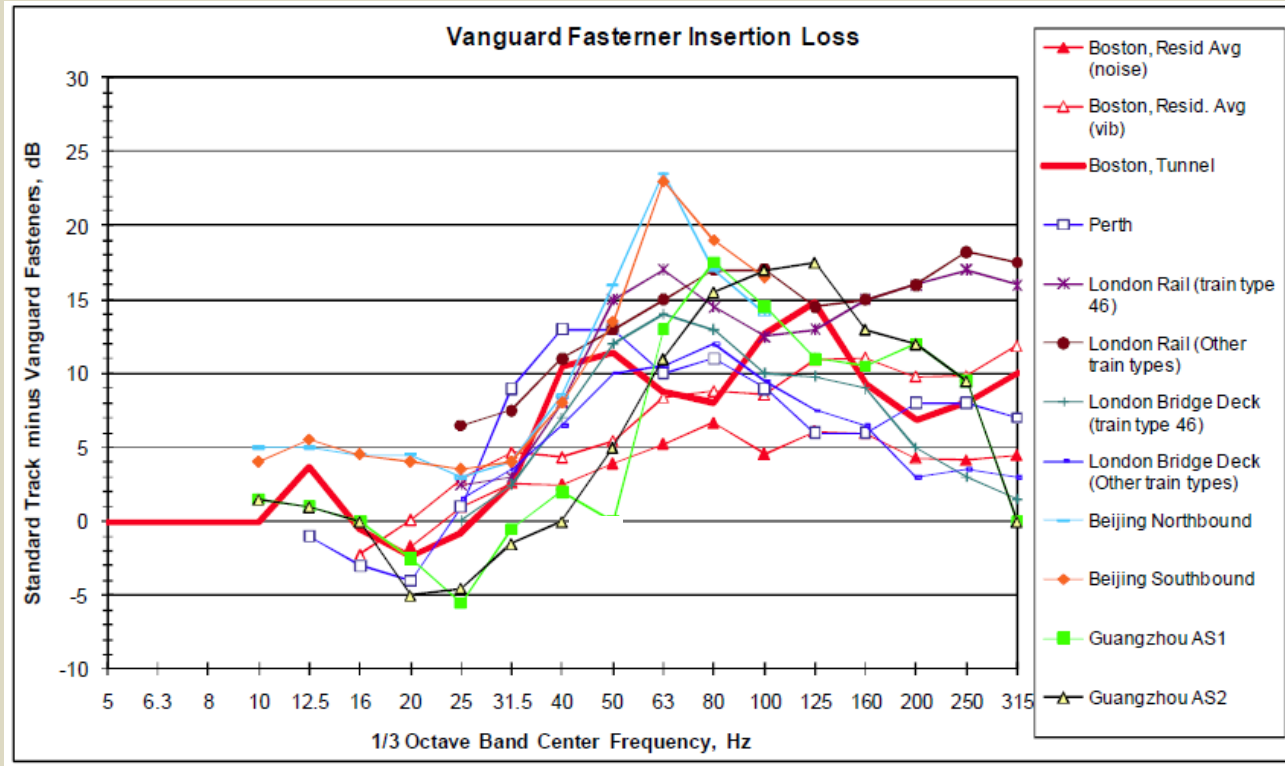


FTA Guidance: Vibration Mitigation

Track Support System	Reduction
Resilient Fasteners (vertical stiffness in the range of 30,000 lb/in)	Reduce vibration by as much as 5 to 10 dB at frequencies above 30 to 40 Hz
Ballast Mats (for ballast-and-tie track)	10 to 15 dB attenuation at frequencies above 25 to 30 Hz
Tire Derived Aggregate (TDA)	No information included in manual – measurements show similar reduction to ballast mat
Floating Slabs	Effective at frequencies greater than their single-degree-of-freedom vertical resonance frequency (no attenuation values specified)

Resilient Fasteners

Source: Pandrol



Vanguard Fastener

<http://www.pandrol.com/product/vanguard>



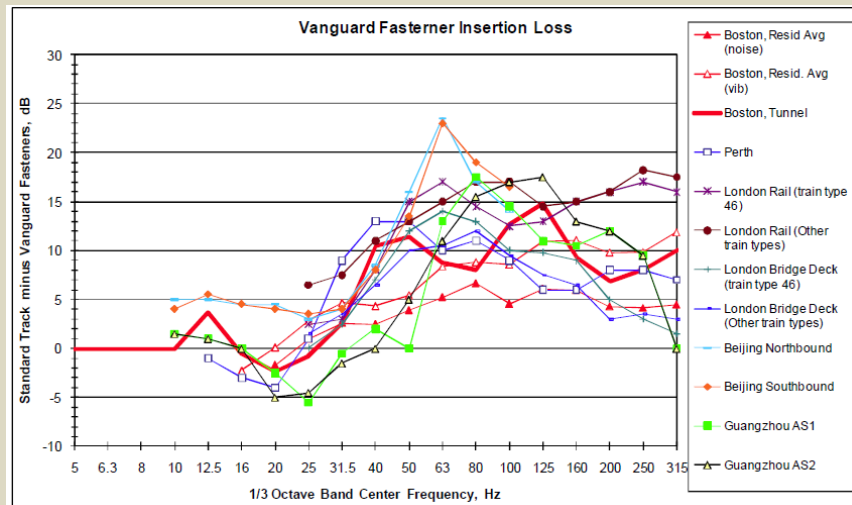
Delkor Egg Fastener

Source: <http://www.delkorail.com/files/2012CompanyOverviewBrochure.pdf>



Resilient Fasteners

- Insertion loss starts at ~30Hz and is optimal in the range 40Hz to 200Hz
- Variation in track structure probably accounts for a lot of the variation in insertion loss
- Knowing the FDL fastener stiffness is important in estimating insertion loss



- Writing an appropriate specification is important in achieving correct amount of attenuation

Ballast Mats

- Rubber mat placed under ballast-and-tie track
- Can be installed on top of a support layer (concrete or asphalt slab) – insertion loss modeling by HMMH in 2005
- Can be installed without support layer directly on sub-ballast. Attenuation curve developed by ATS Consulting for Expo Phase I analysis



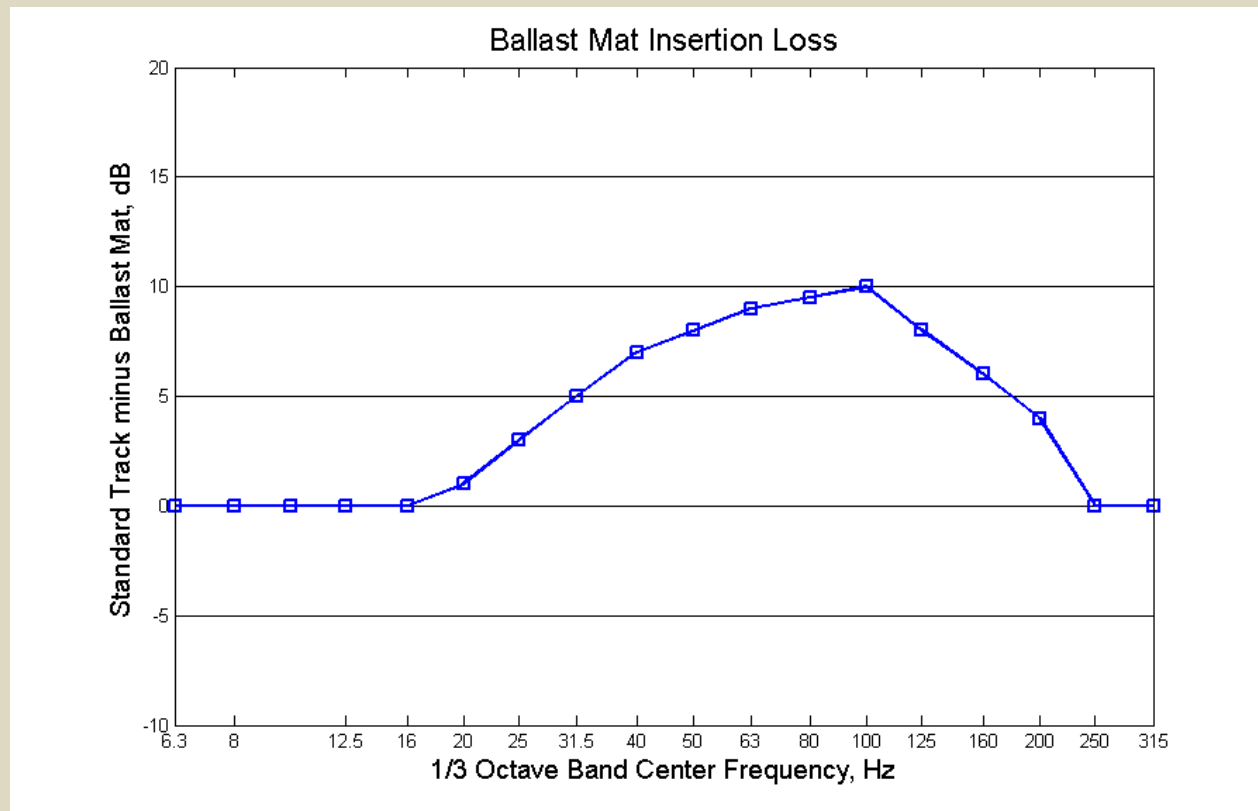
Source: <http://www.railway-technology.com/contractors/noise/pdt/pdt3.html>



Source: Amsted RPS

Ballast Mats

- Insertion loss shown below assumes no support layer.
- Insertion loss may be greater if ballast mat is placed on top of a support layer.



Tire-Derived Aggregate (TDA)

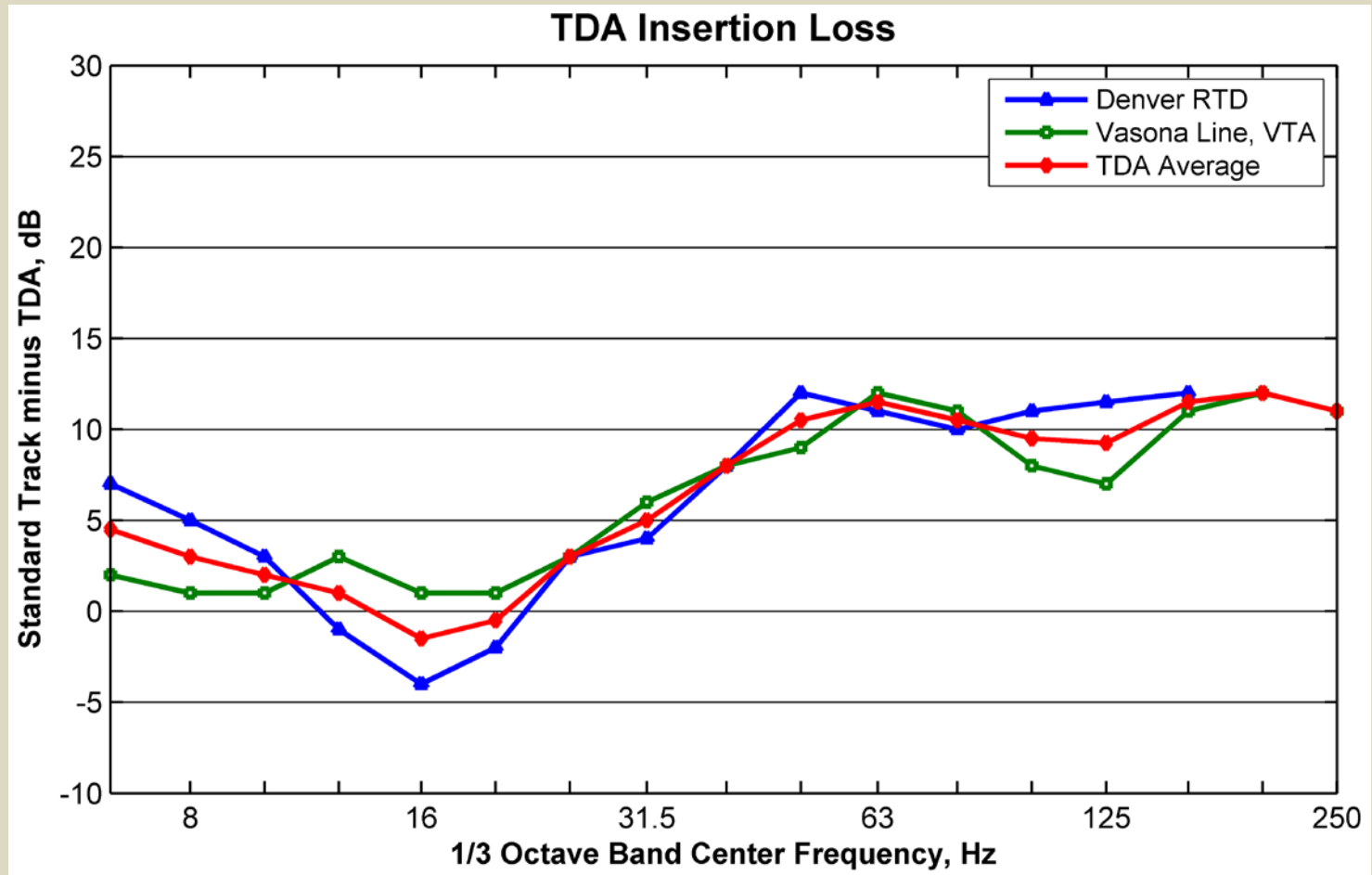
- Similar performance to ballast mat:
 - Denver RTD Light Rail System (study by HMMH)
 - Vasona Line of Santa Clara Valley Transportation Authority (study by WIA)
- Recent Installations
 - Metro Gold Line Foothill Extension (under construction)
 - Calgary CTrain West Extension (in operation)
- Lower material cost compared to ballast mat

Source: <http://www.calrecycle.ca.gov/Tires/TDA/Projects/Vasona.htm>



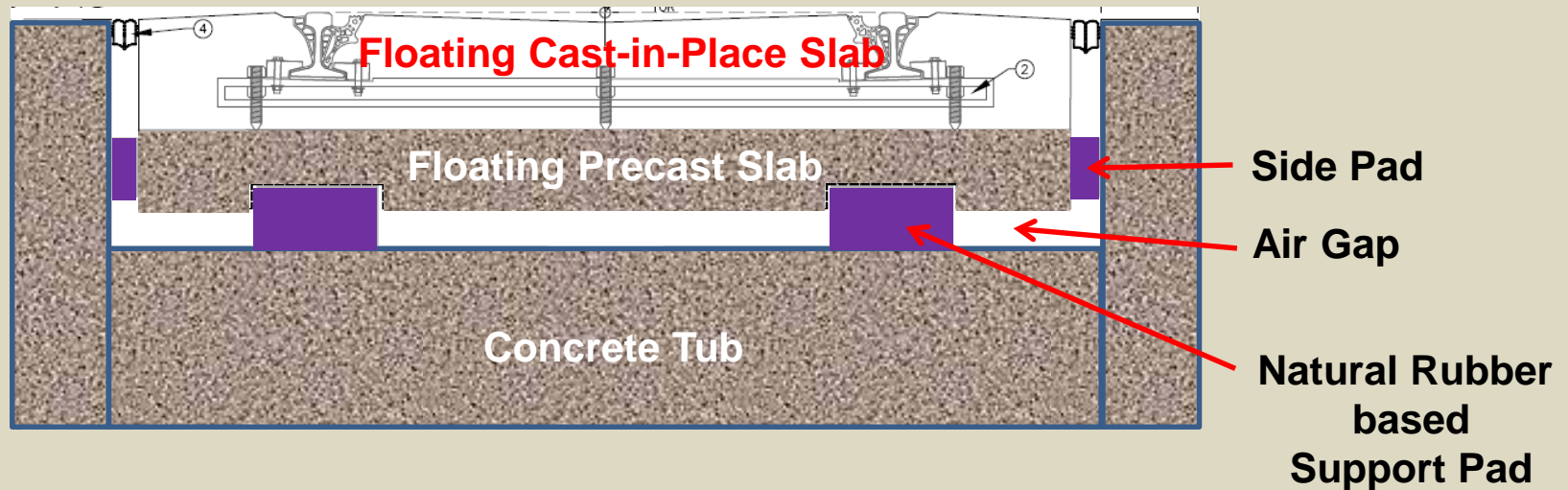
- Generally install 2' thick layer (higher construction costs compared to ballast mat)

Tire-Derived Aggregate



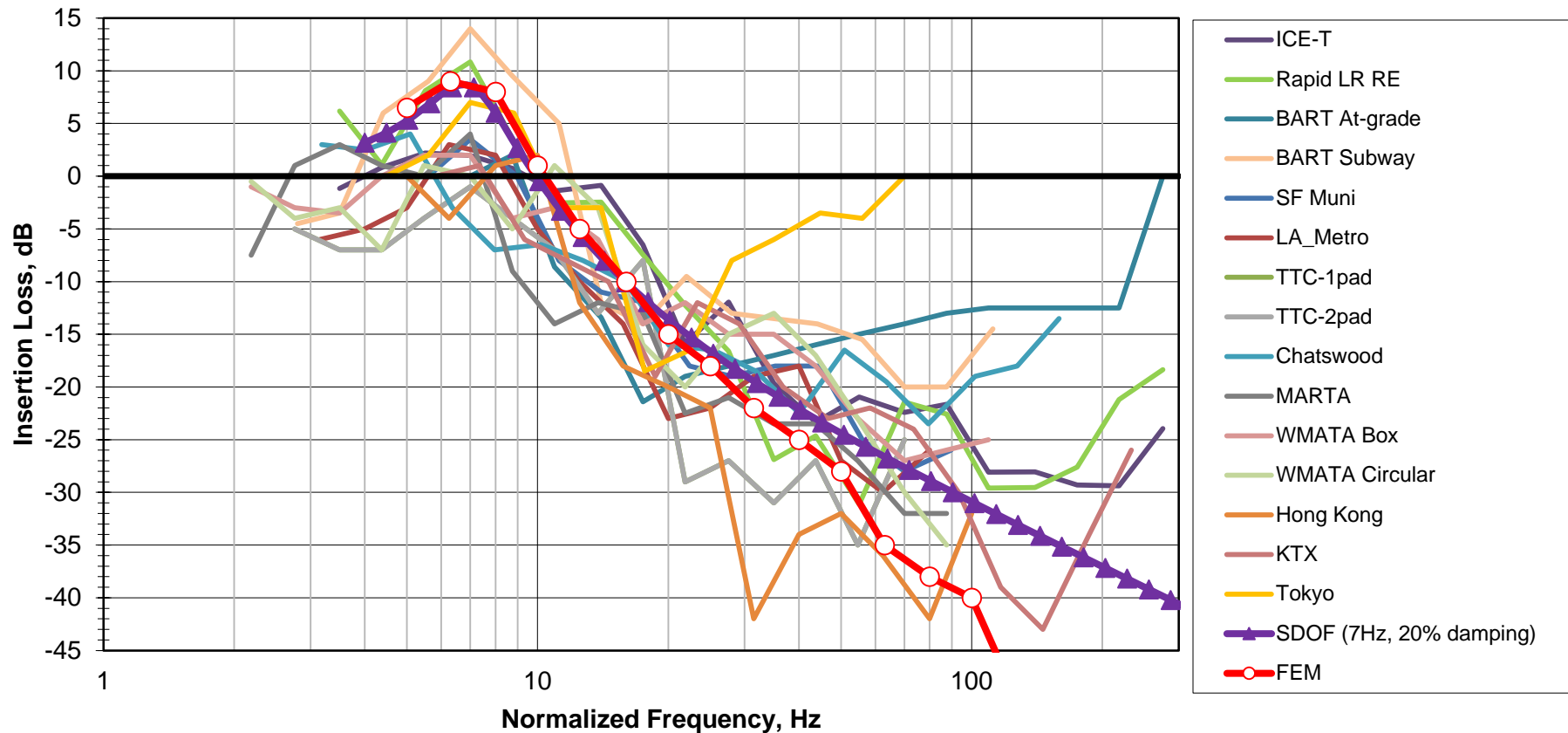
Floating Slab Track

- Can provide the greatest amount of mitigation over the widest frequency range
- High cost and may not be suitable for shared rights-of-way



Floating Slab Track

- The resonant frequency is designed to fit the needs of the project
- The SDOF model is suitable for predicting FST performance



Conclusions

- There are more mitigation measures available than are listed in the FTA Guidance Manual and there are alternatives to sound walls
- Many mitigation measures require detailed analysis and design that occurs after the environmental assessment
- Writing a good specification and consulting with suppliers is key to achieving the desired performance

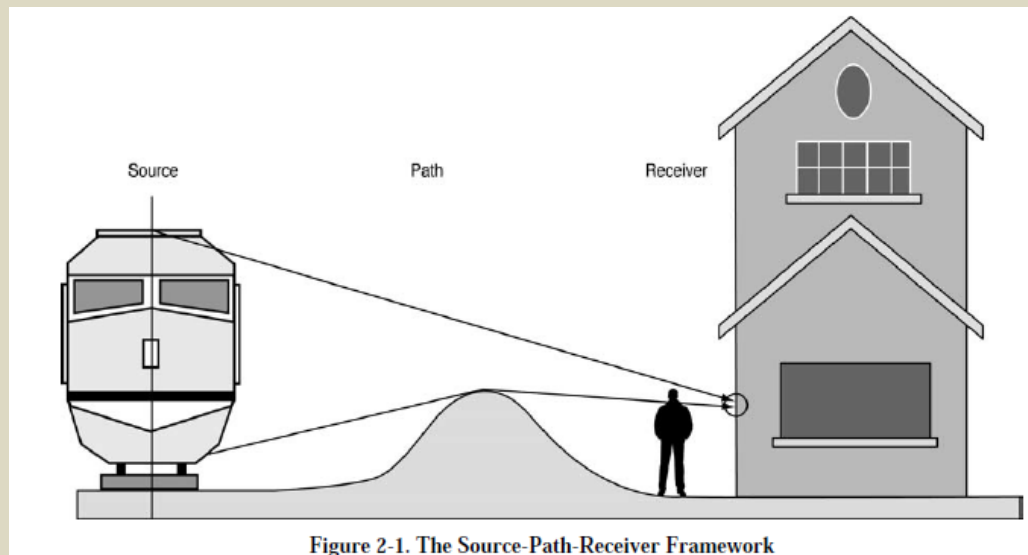


Figure 2-1. The Source-Path-Receiver Framework

Sources

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