METRO BLUE LINE EXTENSION

Bottineau LRT

Transit Noise and Vibration Overview

May 12 and 13, 2015

METROPOLITAN COUNCIL

Metro Transit

FTA

Counties Transit Improvement Board

Minnesota Department of Transportation

Hennepin

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Workshop Agenda

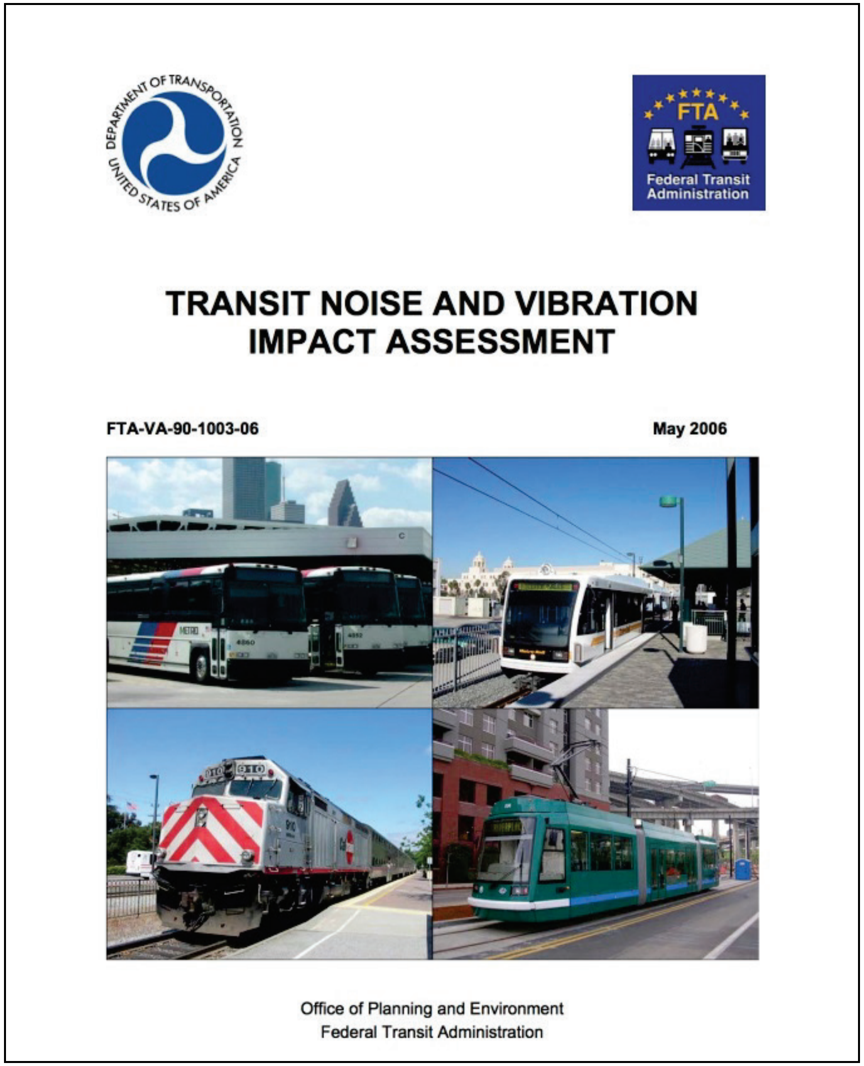
- Welcome and Introductions
- Workshop Goals and Outline
- Noise
- Questions/Answers
- Workshop Break
- Vibration
- Questions/Answers

Workshop Goals

- The goals of the workshop are to provide stakeholders with information on:
  - How Federal Transit Administration (FTA) guidance is used to assess and mitigate transit noise and vibration
  - What are the basics of noise and vibration
  - How are noise and vibration measured and modeled
  - What are noise and vibration impacts
  - What are the criteria for determining impacts
  - What mitigation options are available
- Participants will be better prepared to review and understand the information in the Final Environmental Impact Statement (FEIS)

Workshop Outline

- Noise
  - Basics
  - Criteria
  - Assessment Methods
  - Mitigation Options
  - Construction
- Vibration
  - Basics
  - Criteria
  - Assessment Methods
  - Mitigation Options
  - Construction



TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT

FTA-VA-90-1003-06

May 2006

Office of Planning and Environment
Federal Transit Administration

Variables of Sound

- Amplitude (loudness)
- Frequency (pitch)
- Time pattern

Loudness

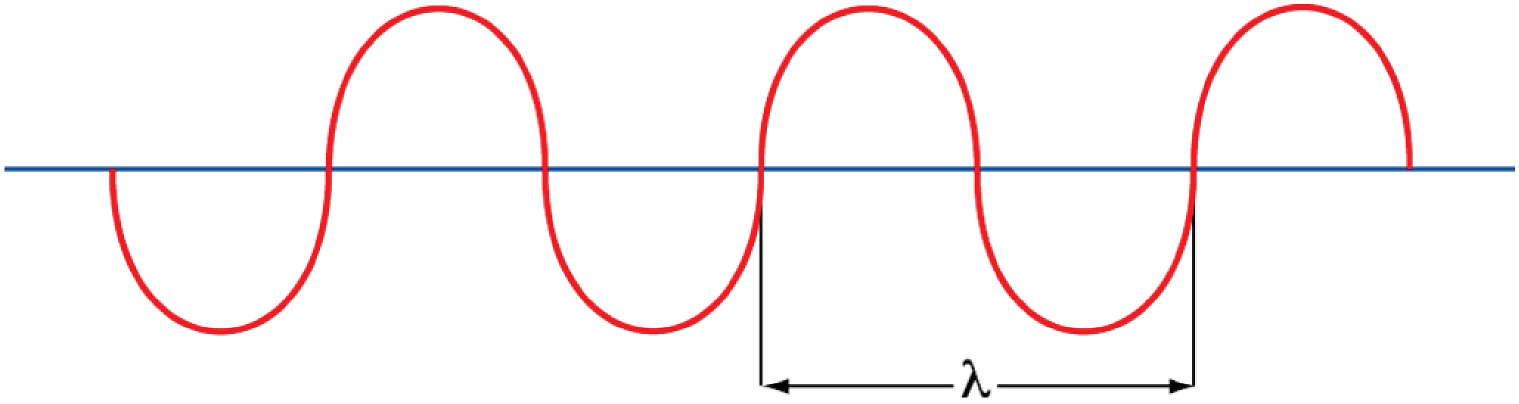
- Sound: rapid fluctuations in atmospheric pressure
- Sound pressure level (SPL): ratio of the measured pressure to a reference pressure
- Decibels (dB): unit of SPL, uses a logarithmic scale

Sound Pressure Level (dB)	Sound Pressure (micro-pascals)
0	20
60	20,000
120	20,000,000

Frequency: Pitch

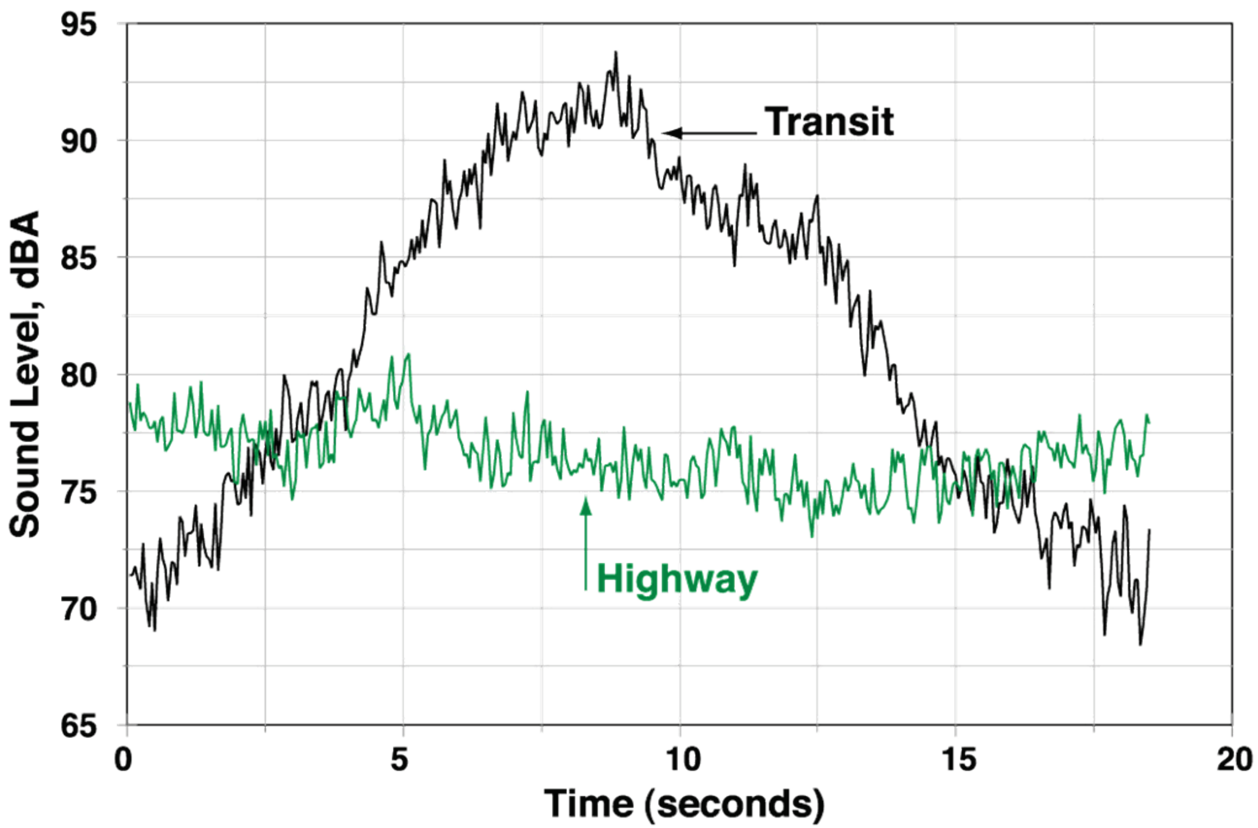
- Under normal conditions the speed of sound is approximately 1000 feet per second

For a frequency of 1000 Hz, the wavelength is1 foot
For a frequency of 500 Hz, the wavelength is 2 foot
For a frequency of 100 Hz, the wavelength is10 foot



Time Pattern

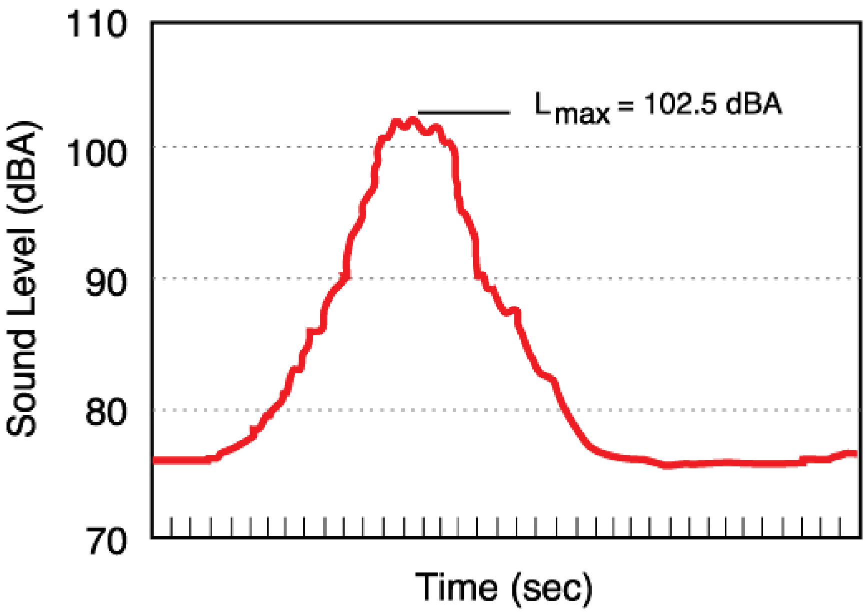
- Steady
- Intermittent
- Transient

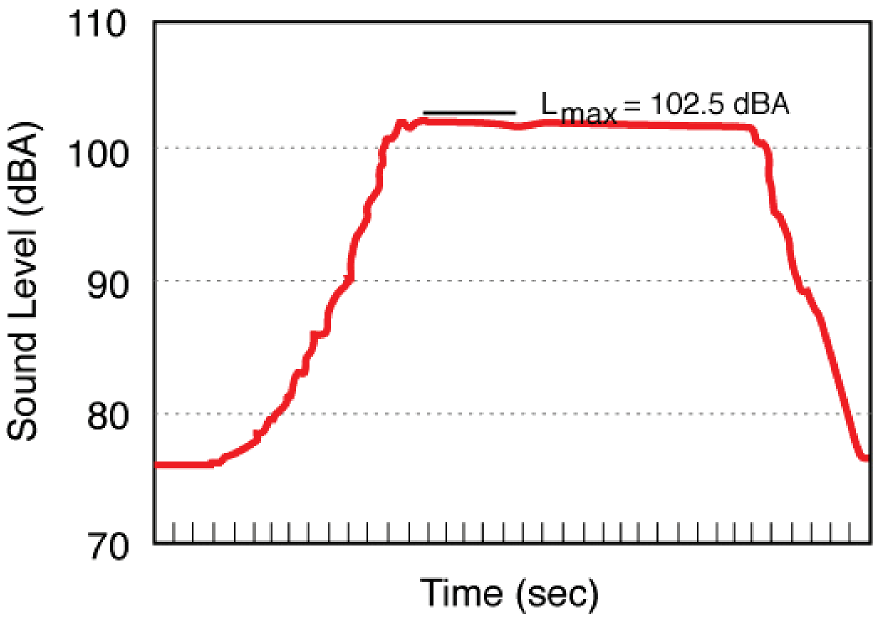


Defining Transit Noise

- A-Weighted Sound Level: dBA
  - Instantaneous sound level
- Maximum Noise Level: L_{max}
  - Loudest noise level for a specific event
- Equivalent Sound Level: L_{eq}
  - Cumulative noise over a period of time
  - Describes community response to noise
- Day-Night Sound Level: L_{dn}
  - The most widely used environmental noise metric

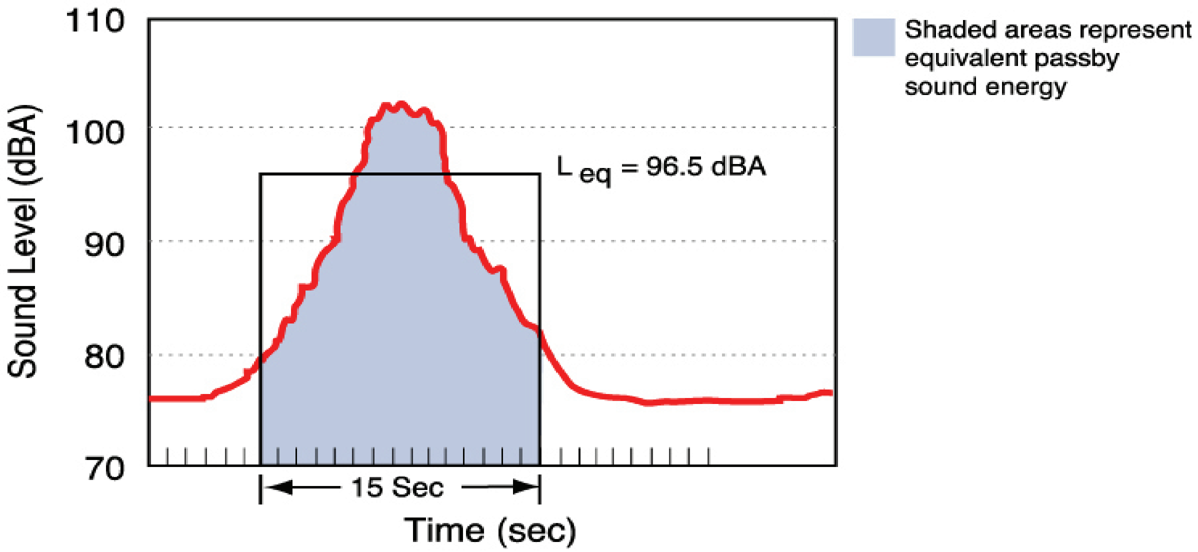
Maximum Noise Level (L_{max})





Equivalent Sound Level (L_{eq}/L_{dn})

- Cumulative noise exposure
- Equivalent to changing noise over time period
- Ldn is the descriptor for 24-hour exposure
- Defined as 24-hour L_{eq} with 10 decibel penalty applied to nighttime noise

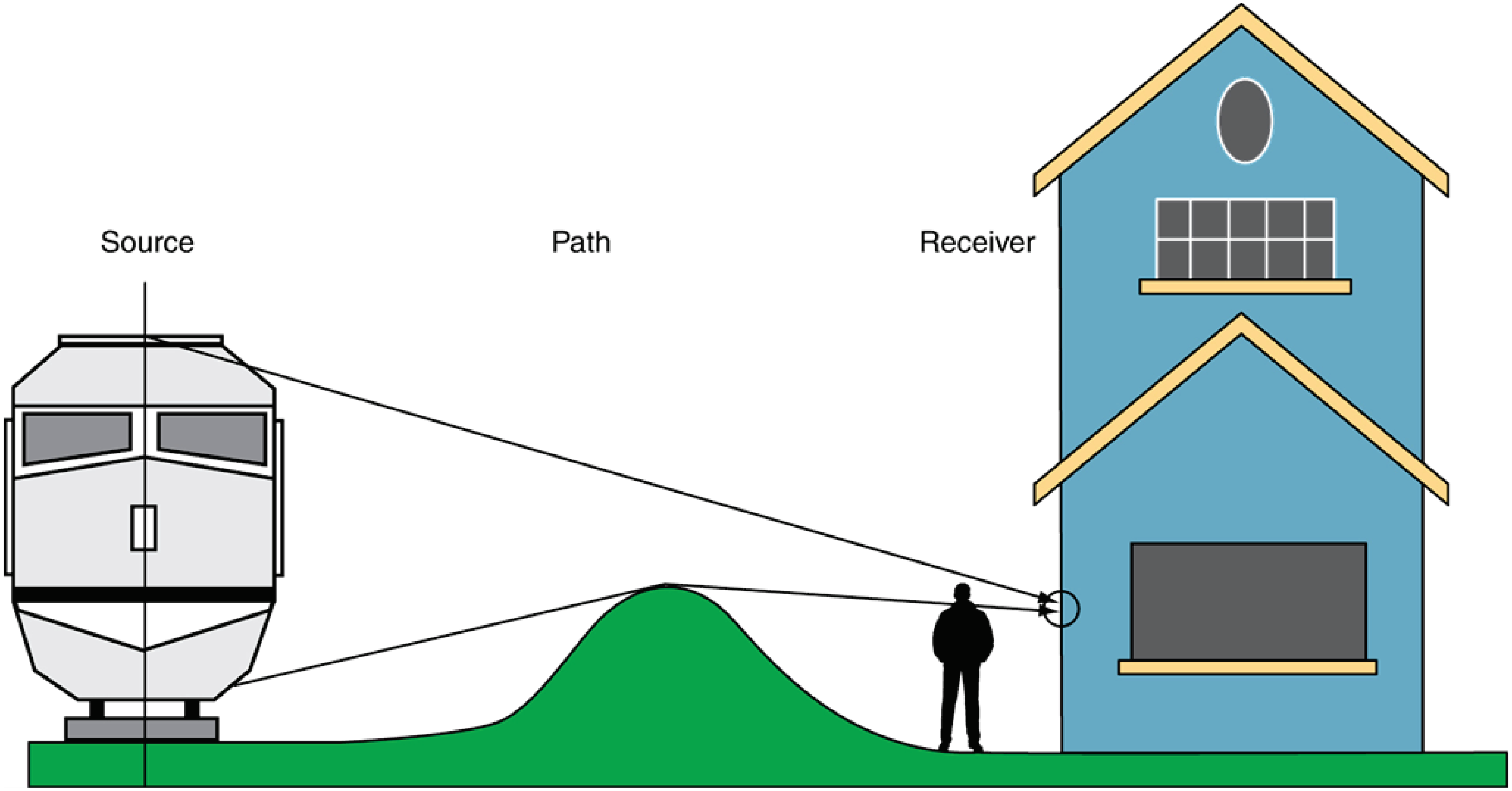


Adding Decibels

- How to we add two sources of noise?
- Decibels are on a logarithmic scale, so direct addition does not work
- We add the energy of two sources
- Easy way to add decibels

When two decibel values differ by:	Add to the higher value:
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 8 dB	1 dB
9 dB or more	0 dB

Source-Path-Receiver

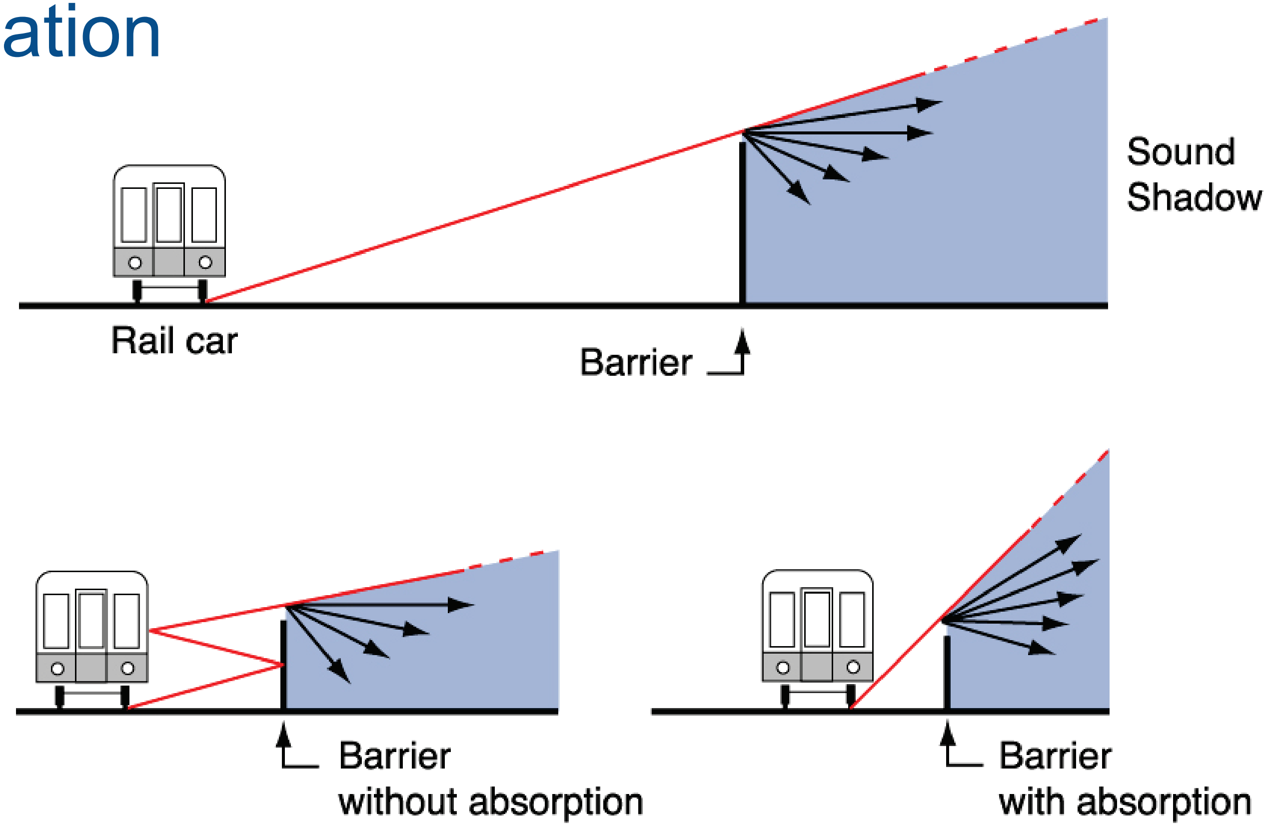


Sources of Transit Noise

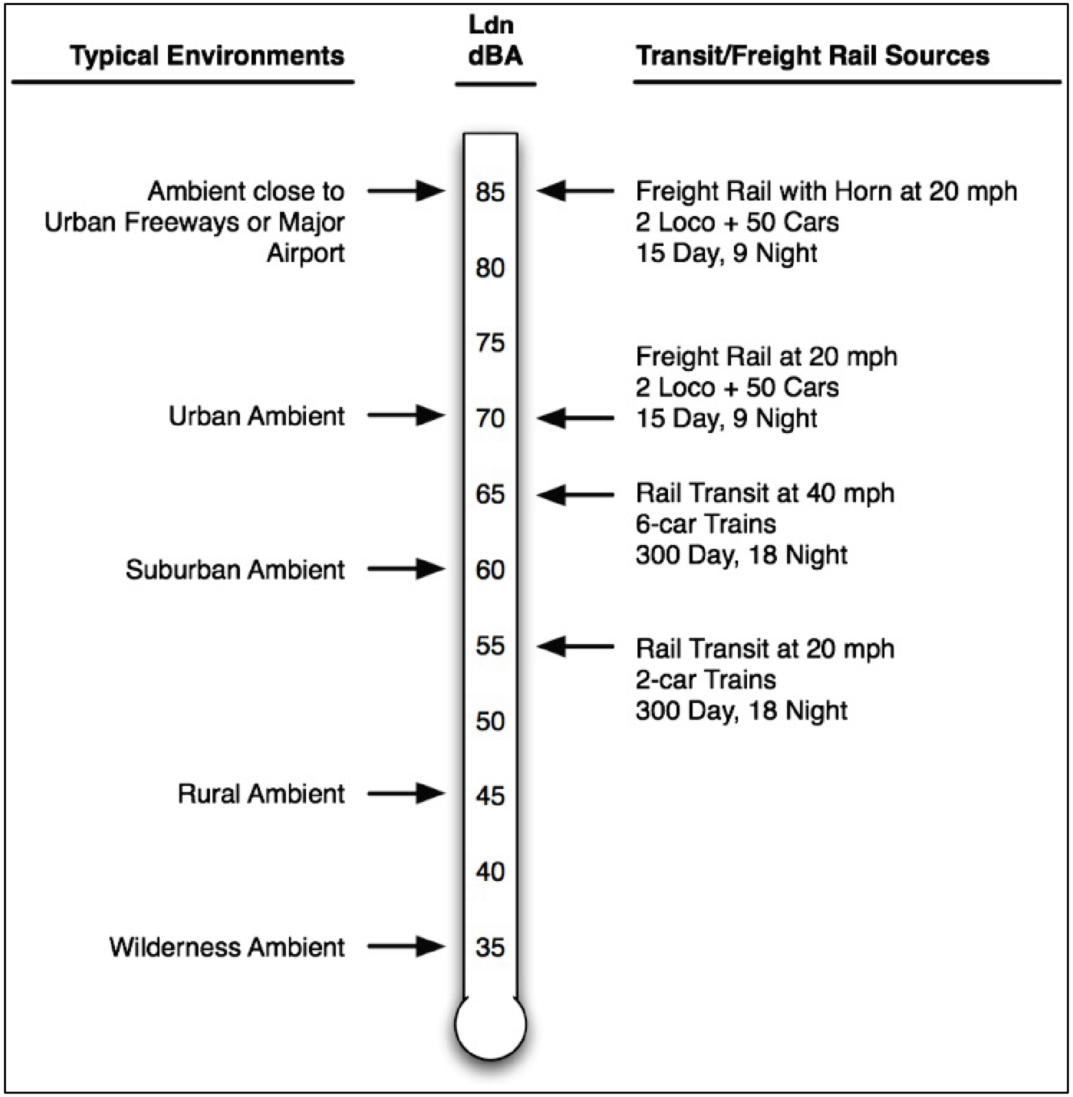
- LRT/Streetcars
  - Wheel/rail interaction
  - Propulsion system
  - Wheel squeal
  - Horns and bells
- Commuter rail vehicles
  - Diesel engine, exhaust & fans
  - Wheel/rail interaction
  - Horns and bells
- Stations
  - Automobile and bus traffic
  - Vehicle idling
  - P.A. systems
- Buses
  - Diesel engine, exhaust & fans
  - Traction motors (electric buses)
  - Tire/roadway
- Maintenance/storage yards
  - Vehicle activity
  - Signal horns and bells
  - P.A. systems
  - Impact tools
  - Vehicle washers/driers

Path Factors for Noise

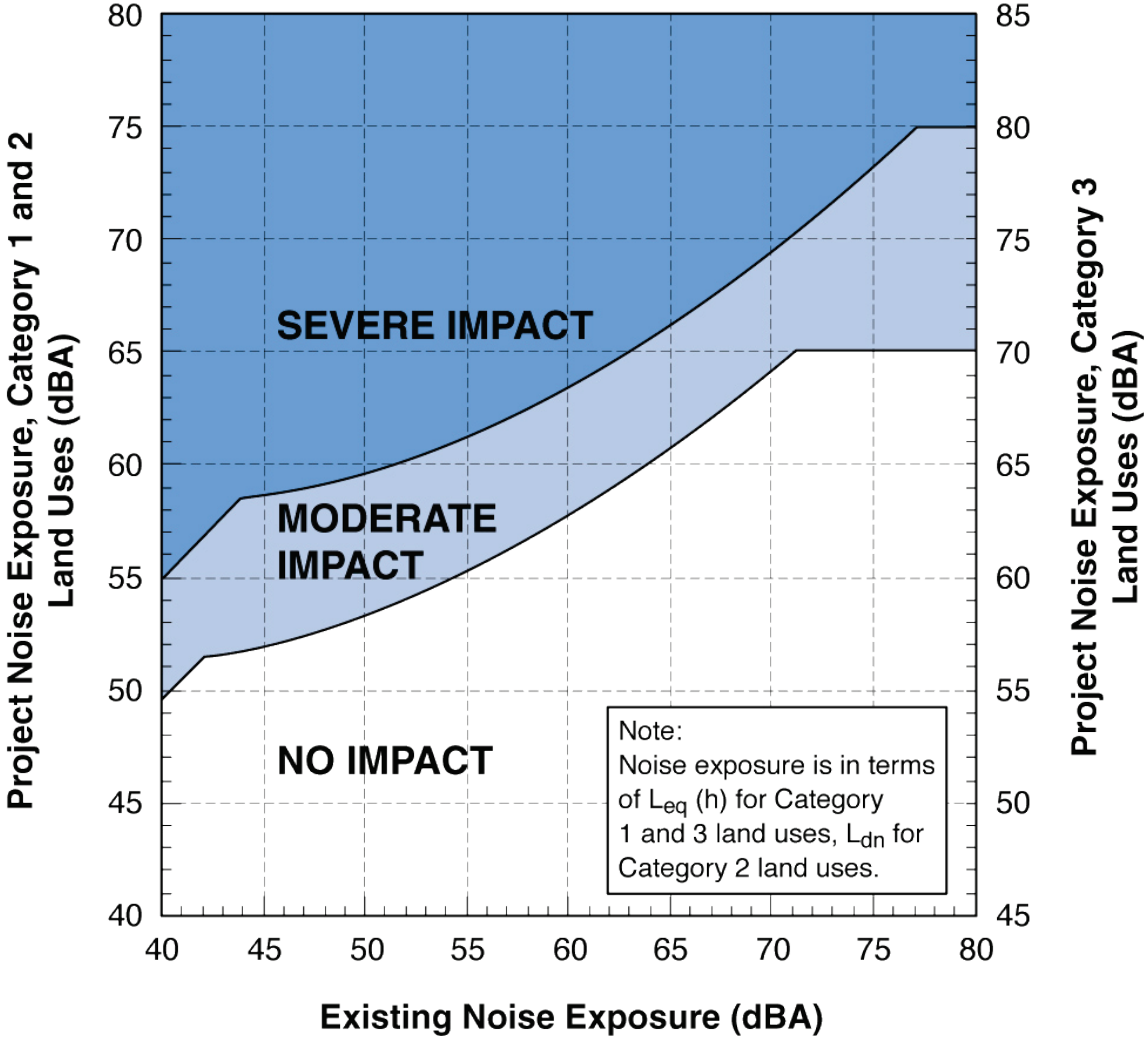
- Divergence
- Atmospheric Conditions
- Ground Attenuation
- Barriers



Typical Noise Levels



FTA Noise Impact Criteria



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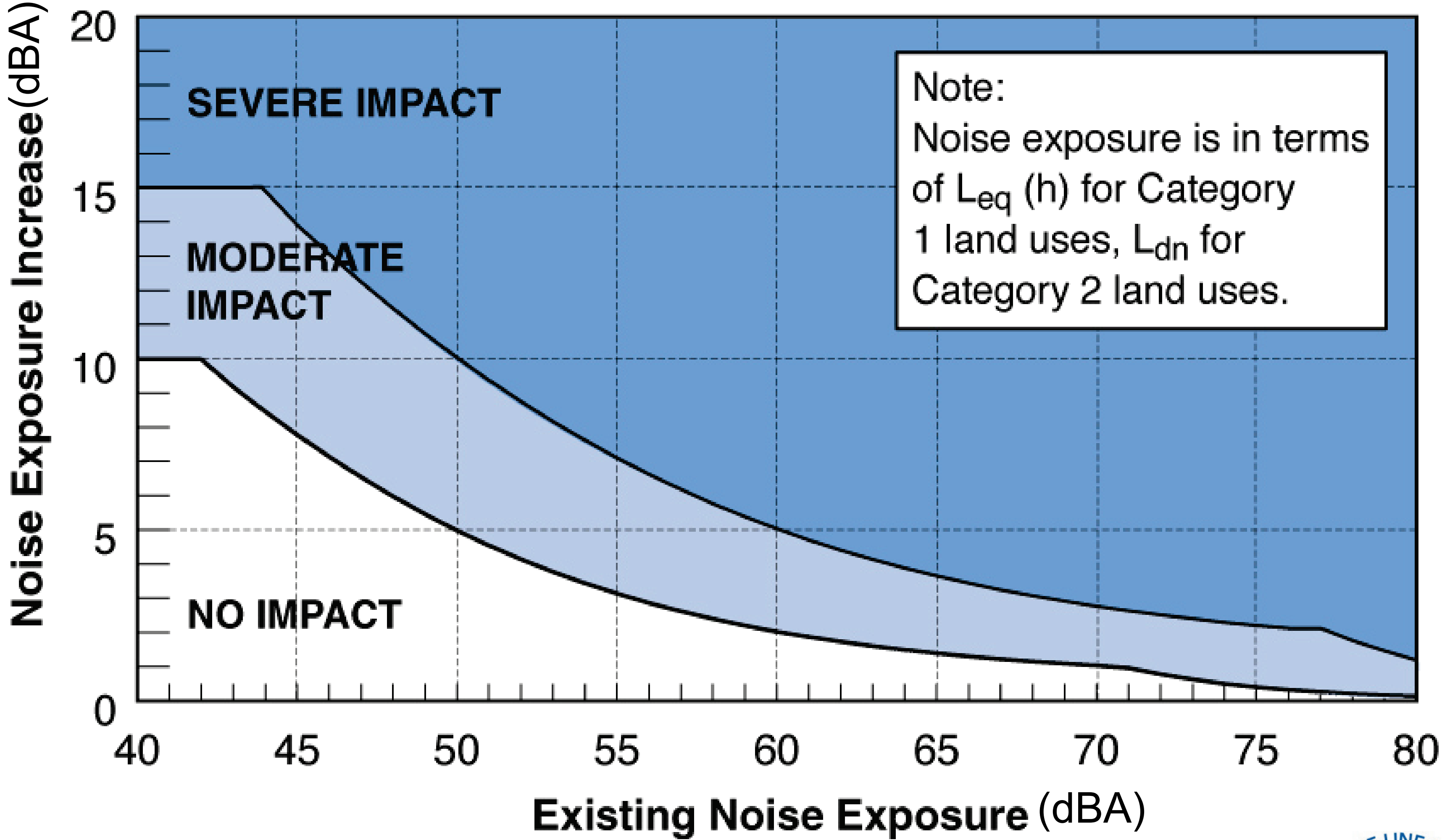


Land Use Categories

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor $L_{eq}(h)^*$	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor $L_{eq}(h)^*$	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

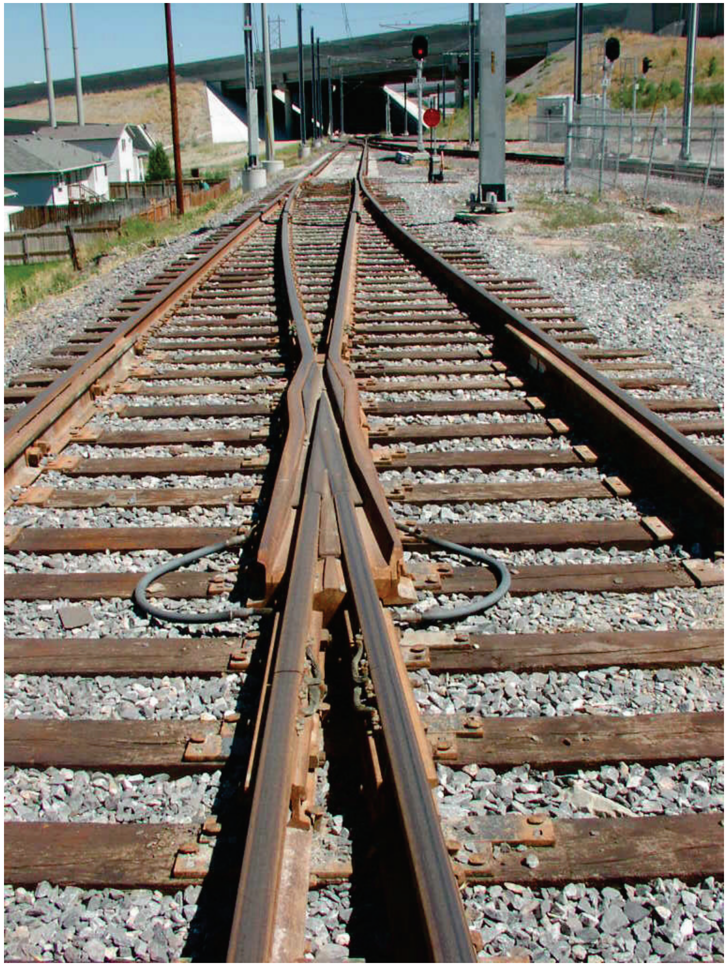
* L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.

Noise Assessment Types

- Screening Assessment
  - Identify areas of potential impact
  - Estimate distances beyond which no impacts are likely
  - If potential for impact exists, conduct a General Assessment
  - If potential for impact does not exist, no further assessment necessary
- General Assessment
  - Next step after Screening
  - All that is needed for many smaller transit projects
  - Used to evaluate alternatives
  - Identifies locations where mitigation may be needed
  - Use FTA noise assessment spreadsheet

Noise Assessment Types

- Detailed Assessment
  - Site-specific analysis for mitigation
  - Detailed project information
  - FEIS, preliminary engineering, design
  - Items included:
    - Grade-crossing noise
    - Curve squeal
    - Propagation characteristics
    - Ground effects
    - Shielding by buildings and barriers
    - Crossovers and special trackwork



Noise Assessment Inputs

- Number of cars per train
- Number of trains per hour
- Speed
- Hours of operation
- Source noise level
- Path factors
- Track type
- Distance

METRO BLUE LINE EXTENSION
Bottineau LRT

Combined Transit and Roadway Projects

- Two projects assessed independently
  - Blue Line LRT Extension
  - West Broadway Avenue

- Combined effects of both projects (cumulative effects) will be documented in the FEIS for the Blue Line LRT
  - Will include combined LRT and traffic noise
  - Mitigation, if required, will be designed for both projects

FTA Noise Mitigation Policy

- No Impact
  - Mitigation generally not required
- Moderate Impact
  - Mitigation to be considered and adopted, if reasonable
- Severe Impact
  - Seek alternatives to avoid impacts
  - If not practical to avoid, mitigation must be considered

Noise Mitigation

- Source
  - Vehicle noise specs
  - Lubrication/friction modification
  - Wheel truing/rail grinding
  - Vehicle body treatments
  - Wheel treatments
  - Crossovers
  - Quiet zones
  - Wayside horns
- Path
  - Barriers
  - Berms
- Receiver
  - Sound insulation

Construction Noise Sources

- Diesel engines: excavators, backhoes, dozers
- Impacts: jackhammers, pile drivers, hoe rams
- Backup alarms

Construction Typical Noise Levels

Typical Noise Levels at 50 ft (dBA)	
Backhoe	80
Concrete Truck	88
Excavator	82
Hoe-Ram	95
Jackhammer	88
Pickup Truck	60
Pile Driver (Impact)	101

Mitigation of Construction Noise

- Design considerations and project layout
- Sequence of operations
- Alternative construction methods

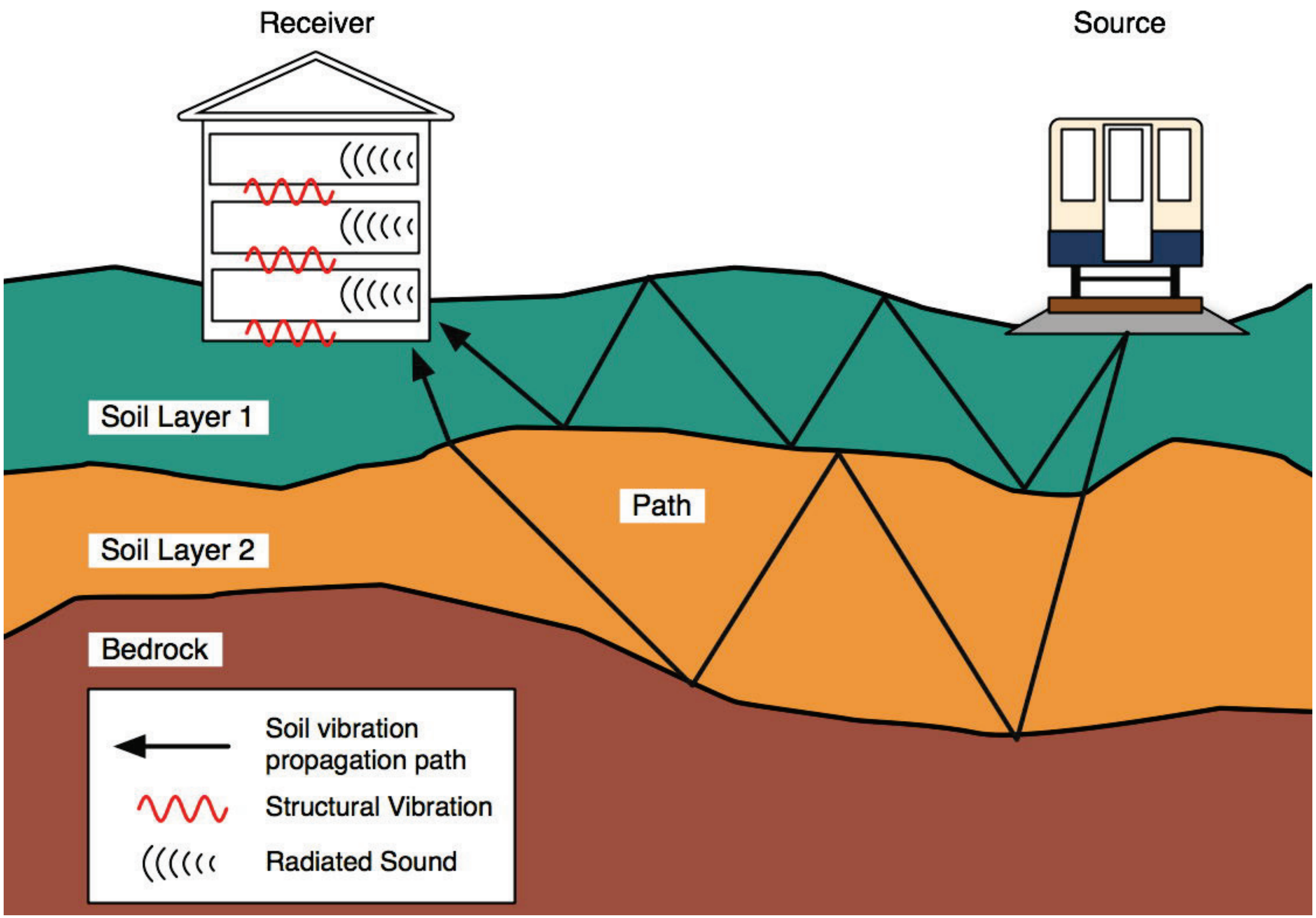
Common Themes: Noise

- Hearing a noise is not necessarily an impact
- Noise barriers will not increase noise levels
- Leq/Ldn is not an “average” and does not present “reduced” noise levels: it is a cumulative noise level
- Active noise control does not work outside
- Speed reductions are not acceptable mitigation
- Trees and vegetation do not work as noise mitigation

Defining Transit Vibration

- Ground-borne vibration: the shaking motion of a building
- Ground-borne noise: the sound generated by shaking of walls, ceilings, floors.
- Use vibration decibels (VdB) to describe vibration
- Use A-weighted sound level (dBA) to describe ground-borne noise

Vibration Source-Path-Receiver



Components of Transit Vibration

- Source
  - Vehicle suspension
  - Wheel/track condition
  - Track support system
  - Speed
  - Transit structure
- Path
  - Soil type/layering
  - Rock layers
- Receiver
  - Foundation type
  - Building construction

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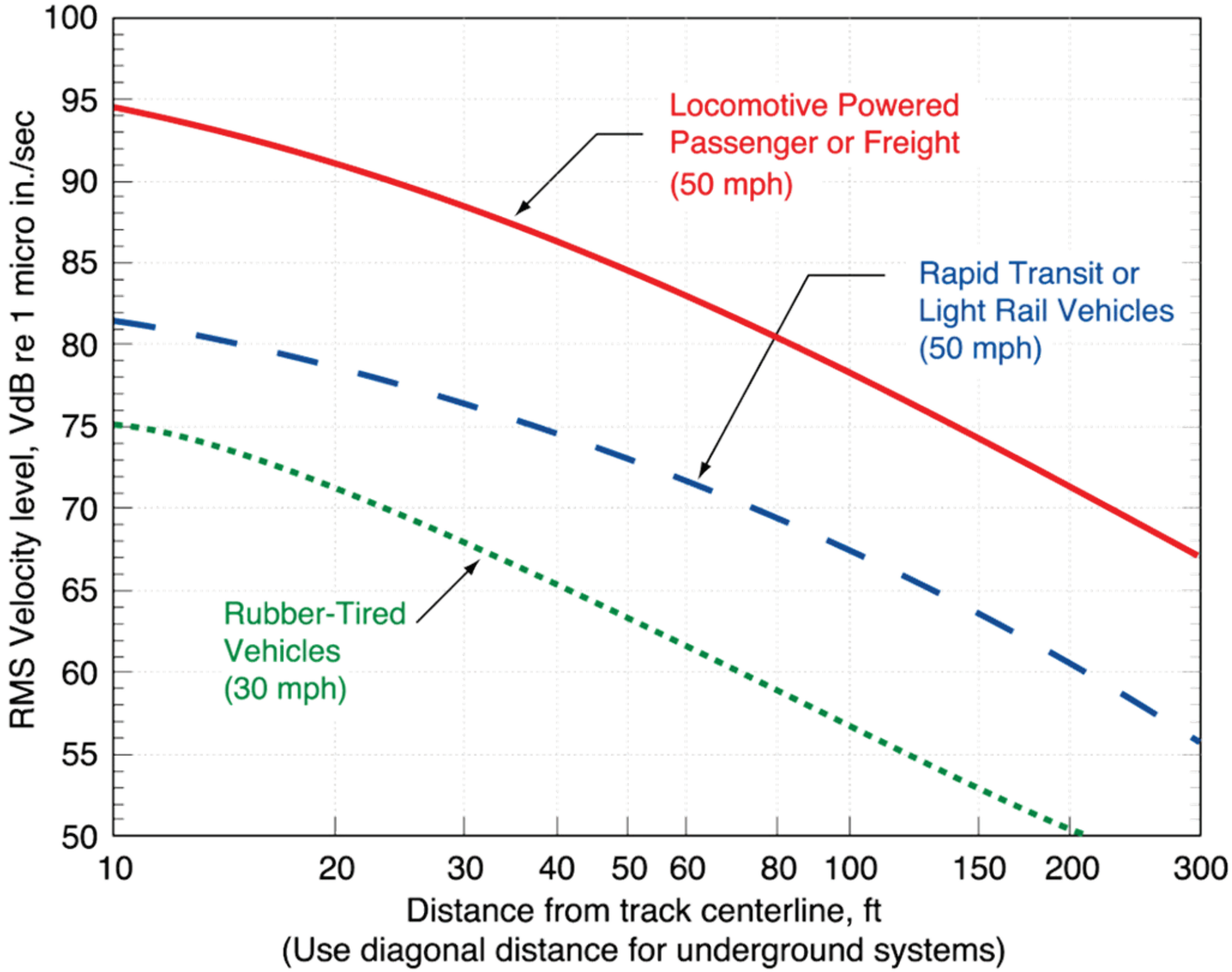
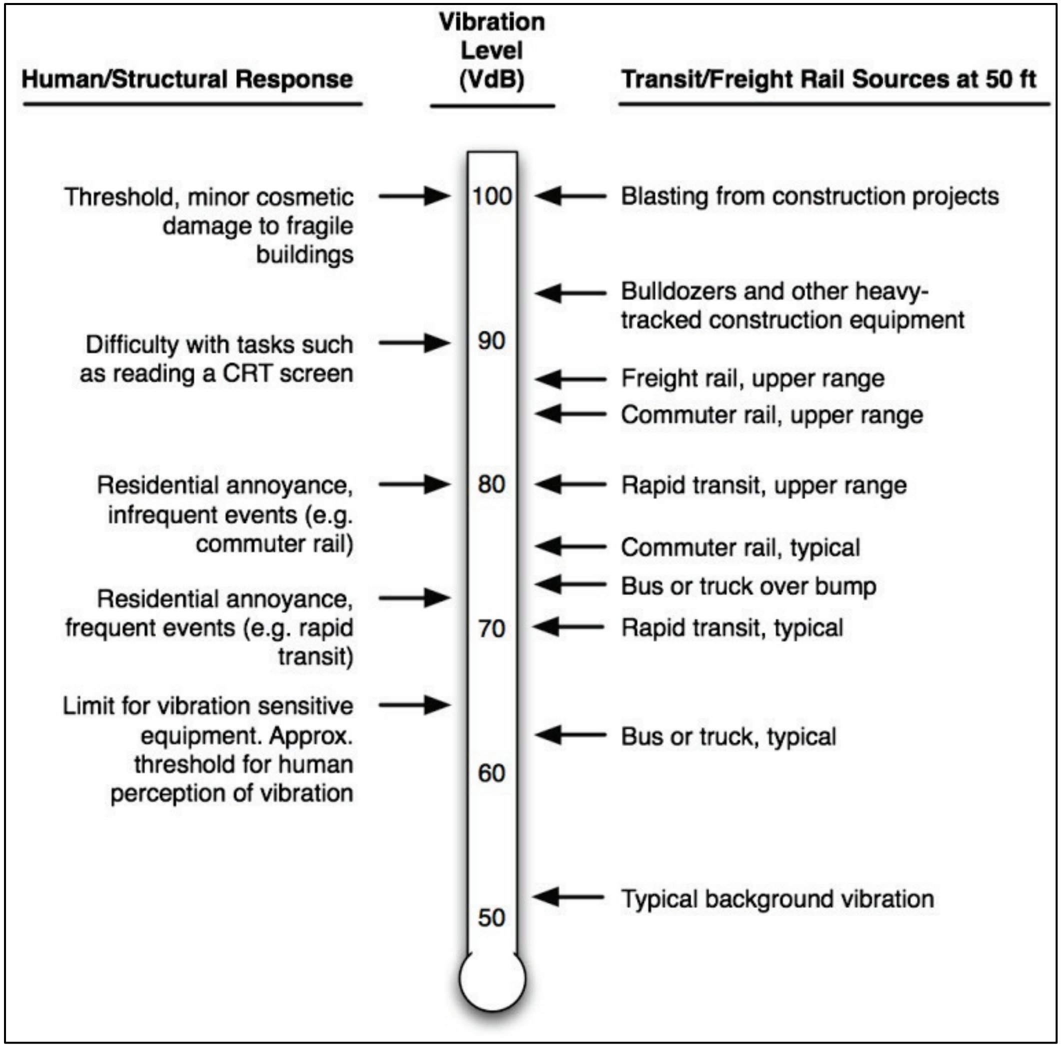
Bottineau LRT

Transit Vibration



Typical Vibration Levels



Vibration Criteria: General

Land Use Category	GBV Impact Levels (VdB)			GBN Impact Levels (dBA)		
	Frequent Events	Occasional Events	Infrequent Events	Frequent Events	Occasional Events	Infrequent Events
Category 1: Buildings where vibration would interfere with interior operations.	65	65	65	N/A	N/A	N/A
Category 2: Residences and buildings where people normally sleep.	72	75	80	35	38	43
Category 3: Institutional land uses with primarily daytime use.	75	78	83	40	43	48

Vibration Criteria: Special Buildings

Type of Building or Room	GBV Impact Levels (VdB)		GBN Impact Levels (dBA)	
	Frequent Events	Occasional or Infrequent Events	Frequent Events	Occasional or Infrequent Events
Concert Halls	65	65	25	25
TV Studios	65	65	25	25
Recording Studios	65	65	25	25
Auditoriums	72	80	30	38
Theaters	72	80	35	43

Vibration Assessment Types

- Screening Assessment
  - Identify areas of potential impact
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- General Assessment
  - Next step after Screening
  - All that is needed for many smaller transit projects
  - Used to evaluate alternatives
  - Identifies locations where mitigation may be needed
  - Use FTA general assessment methodology

Vibration Assessment Types

- Detailed Assessment
  - Site-specific analysis for mitigation
  - Use for highly sensitive sites
  - FEIS, preliminary engineering, design
  - Complex analytical methods
  - Special instrumentation
  - Detailed project information
    - Track type
    - Vehicle force input
    - Ground propagation response
    - Frequency distribution of vibration
    - Crossovers and special trackwork

Vibration Assessment Inputs

- Speed
- Number of trains per day
- Source Vibration level
- Soil characteristics
- Track Type
- Distance
- Building foundation

Vibration Mitigation

- Source
  - Special trackwork
  - Wheel truing/rail grinding
  - Vehicle specifications
- Path
  - Track support systems
    - Resilient track fasteners
    - Ballast mats
    - Resiliently supported ties
    - TDA underlayment
    - Floating slabs
  - Trenches
  - Buffer zones
- Receiver
  - Building modifications

Construction Vibration Sources

- Compactors/vibratory rollers
- Heavy equipment movement
- Pile driving

Construction Vibration Effects

- Damage vs. annoyance
  - Peak Particle Velocity (PPV) used in damage assessment
    - Typically measured for blasting and other high vibration events
    - Related to the stresses experienced by buildings
  - Velocity level (VdB) used in annoyance assessment
    - A measure of how humans respond to vibration in their environment

Construction Vibration Annoyance Criteria

Land Use Category	GBV Impact Levels (VdB)			GBN Impact Levels (dBA)		
	Frequent Events	Occasional Events	Infrequent Events	Frequent Events	Occasional Events	Infrequent Events
Category 1: Buildings where vibration would interfere with interior operations.	65	65	65	N/A	N/A	N/A
Category 2: Residences and buildings where people normally sleep.	72	75	80	35	38	43
Category 3: Institutional land uses with primarily daytime use.	75	78	83	40	43	48

Construction Vibration Damage Criteria

Structural Category:		PPV Limits
I.	Reinforced concrete and steel structures (without plaster) such as industrial buildings, bridges, masts, retaining walls, and unburied pipelines. Underground structures such as caverns, tunnels, galleries, lined and unlined.	0.5 in/sec
II.	Buildings with concrete floors and basement walls and above-grade walls of concrete brick or ashlar masonry, ashlar retaining walls, and buried pipelines. Underground structures such as caverns, tunnels, and galleries, with masonry lining.	0.3 in/sec
III.	Buildings with concrete basement floors and walls, above-grade masonry walls, and timber joist floors.	0.2 in/sec
IV.	Buildings which are particularly vulnerable or worth protecting.	0.12 in/sec

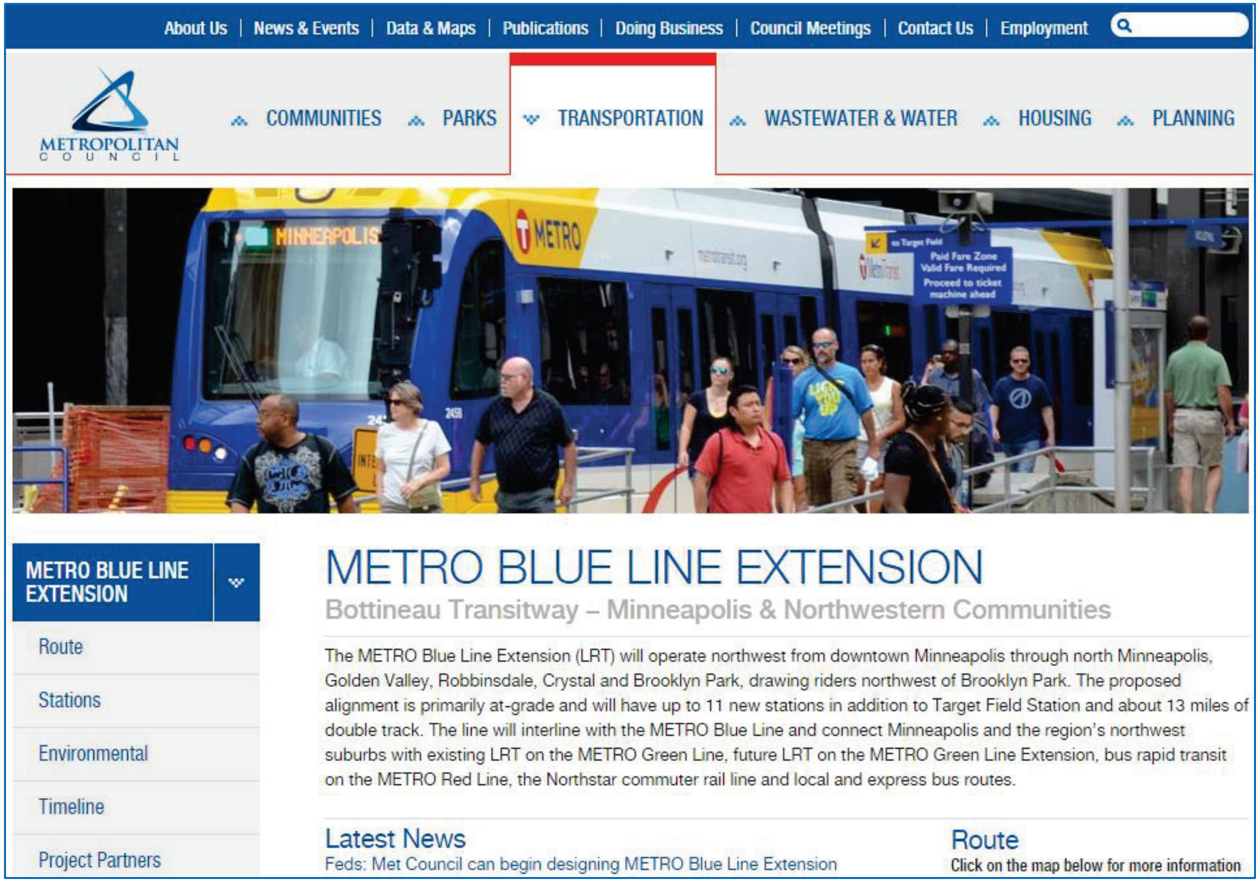
Construction Vibration Mitigation

- Design considerations and project layout
- Sequence of operations
- Alternative construction operations

Common Themes: Vibration

- Transit vibration does not generate high enough levels to cause damage to typical houses
- The threshold for human perception is several orders of magnitude below even the most stringent damage criteria
- Most superficial cracking is due to settlement, changes in the water table and freeze/thaw cycles
- Construction vibration has the potential to cause damage, but only at very close distances for activities such as pile driving
- Trenches are impractical and usually not effective

More Information



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