Wheel and Rail Maintenance for Minimum Noise

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Definitions (1)

- Potential noise sources
  - Rolling noise
  - Squeal from slip-stick interaction on rail head, flange/gauge face contact, restraining rail or guard rail contact
  - Impacts at frogs, joints, bad welds, wheel flats

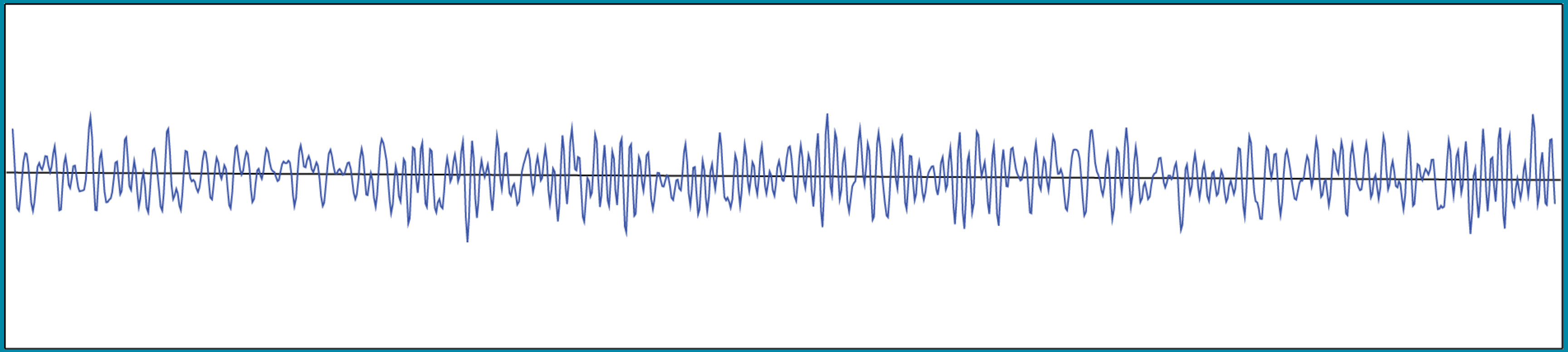
Definitions (2)

- Roughness
  - Random roughness plus periodic roughness (corrugation)
  - Rolling noise is proportional to sum of wheel and rail roughness
- Noise (A-weighted sound level, dBA)
  - Frequency weighted to approximate human hearing

“Roughness”

Any longitudinal irregularity in rail surface

Random Roughness



$$f = \frac{speed}{wavelength}$$

$$= 450 \times \frac{speed\ (mph)}{wavelength\ (mm)}$$

$$= 19 \times \frac{speed\ (mph)}{wavelength\ (in.)}$$

“Roughness”

Any longitudinal irregularity in rail surface

Corrugation

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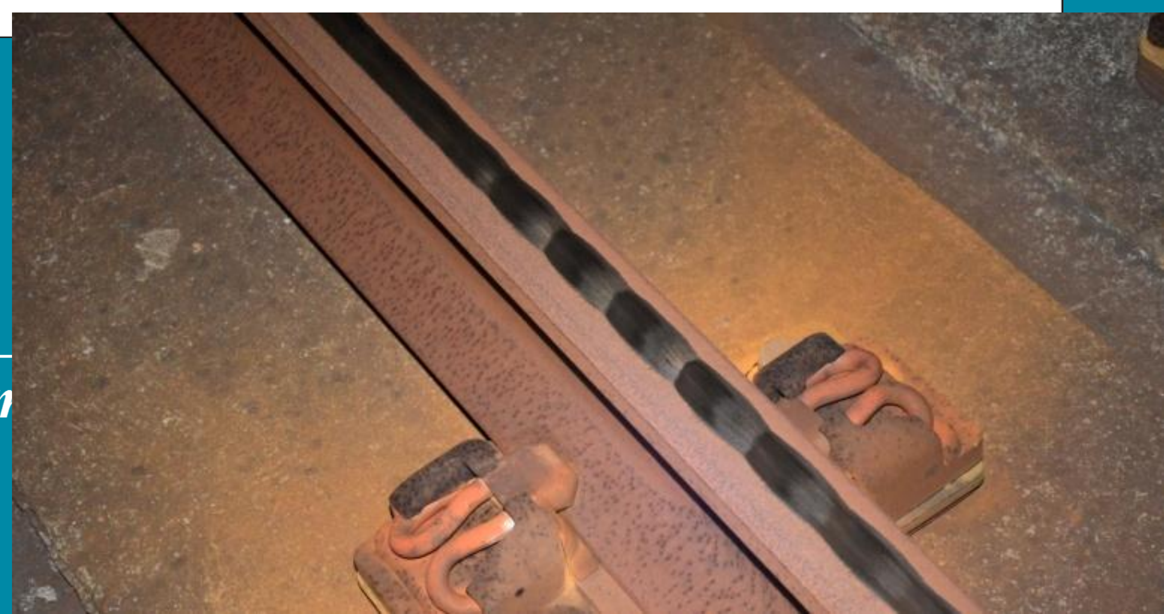
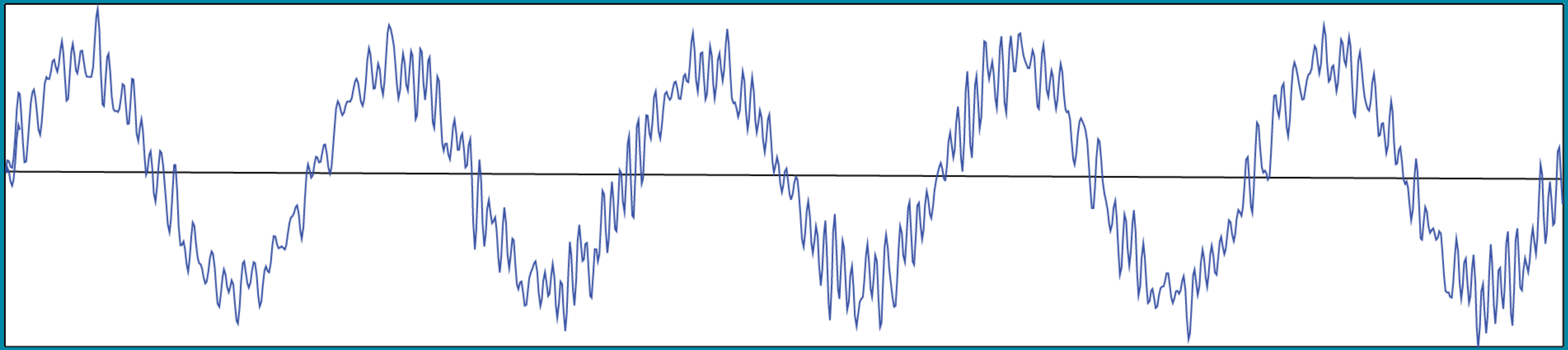


"Roughness"

Any longitudinal irregularity in rail surface

Combined Corrugation and Random



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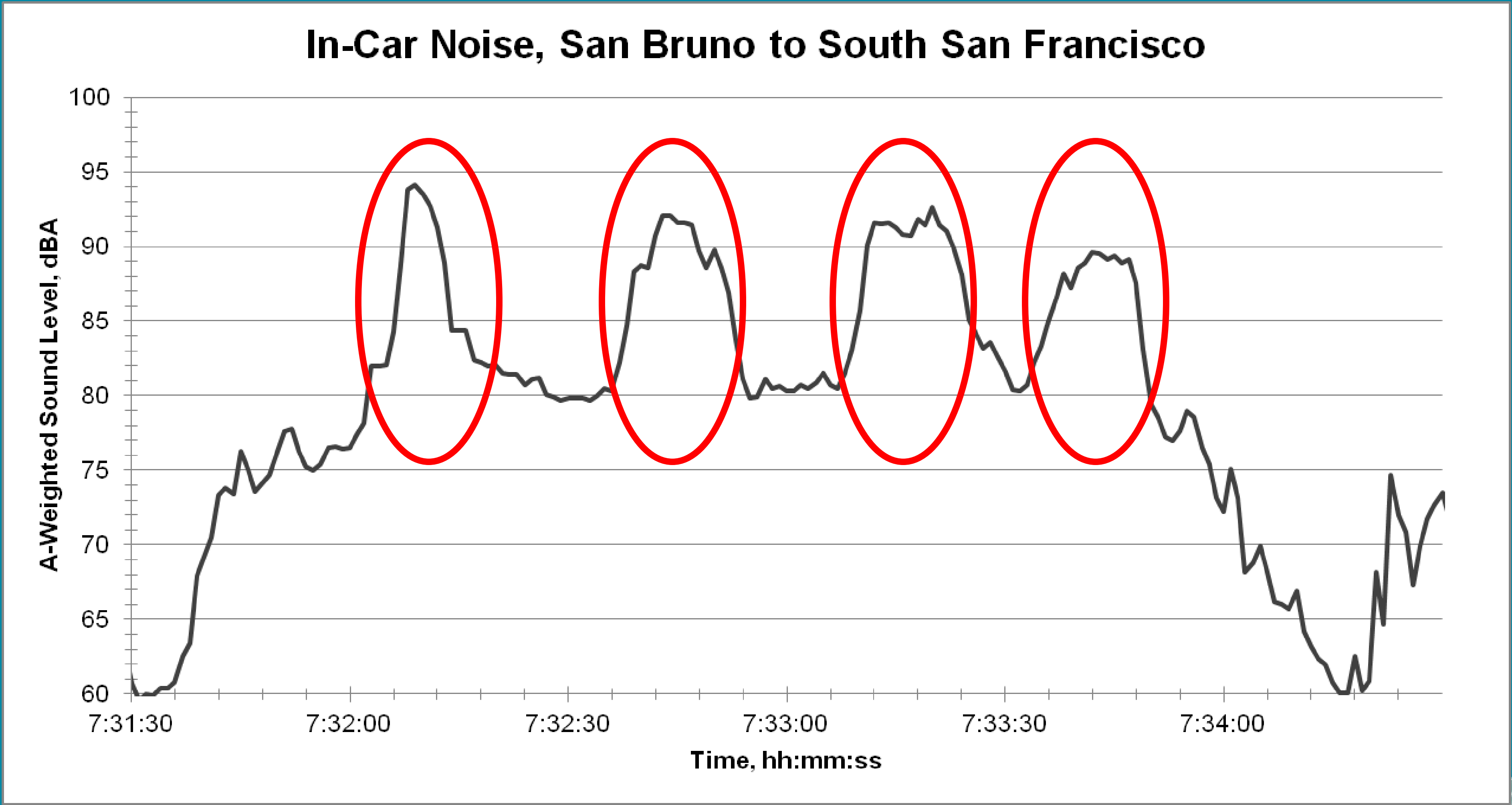
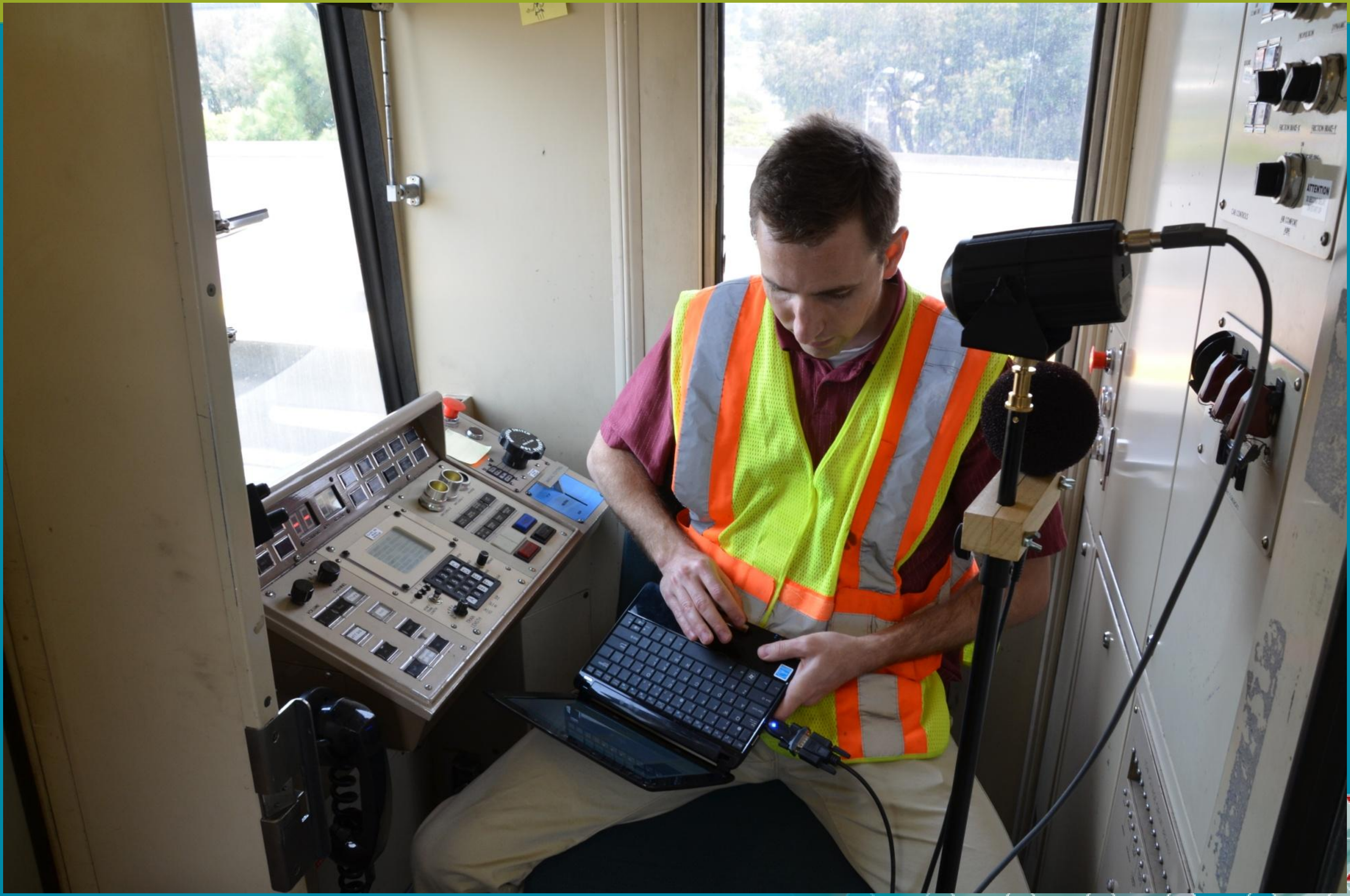
Tools for Evaluating Noise

- On-board noise measurements to identify problem areas
- Detailed measurements at selected sites
  - Community noise
  - Noise at 1m from near rail
  - Rail roughness
  - Rail vibration decay rate

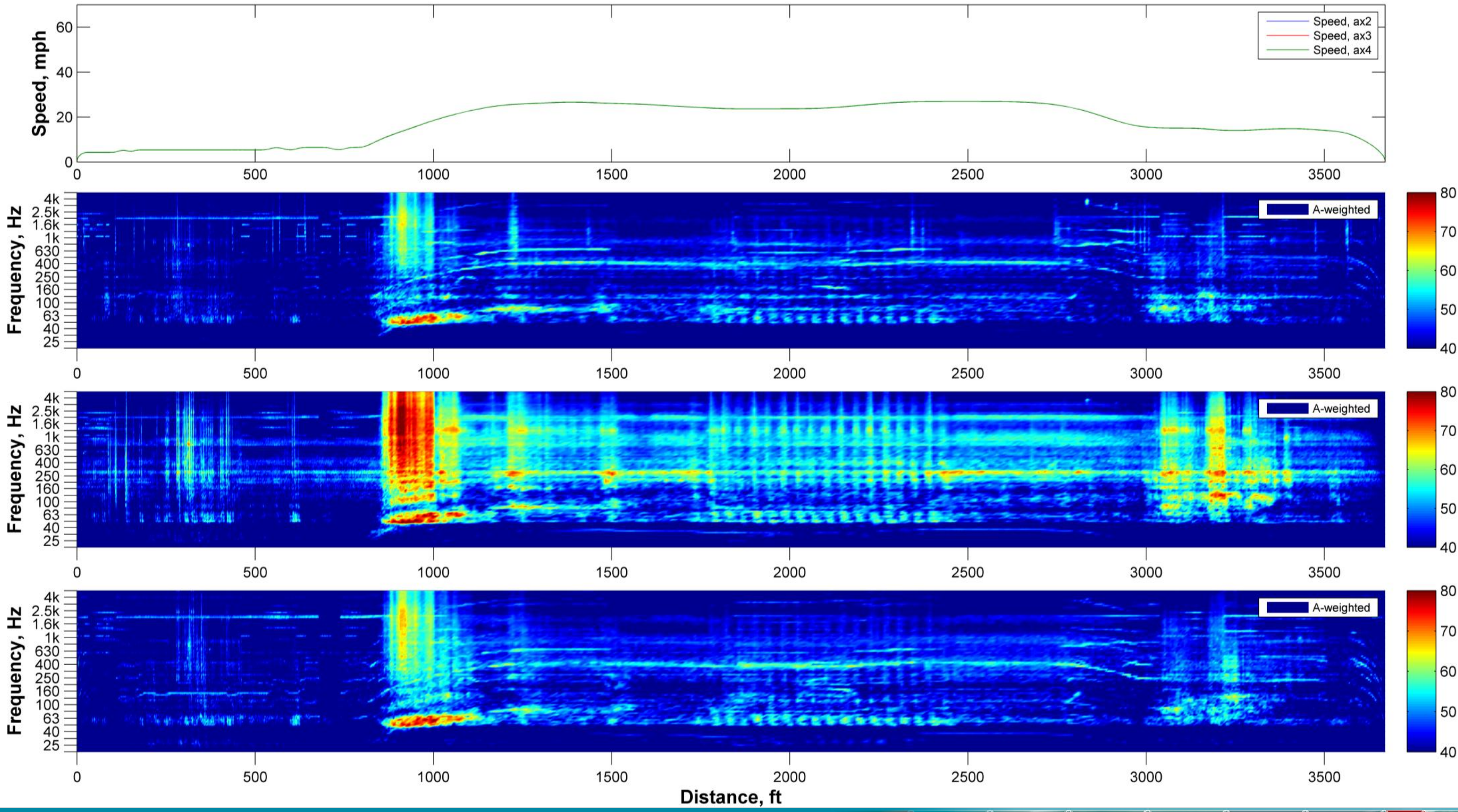
On-Board Noise Measurement, 2003



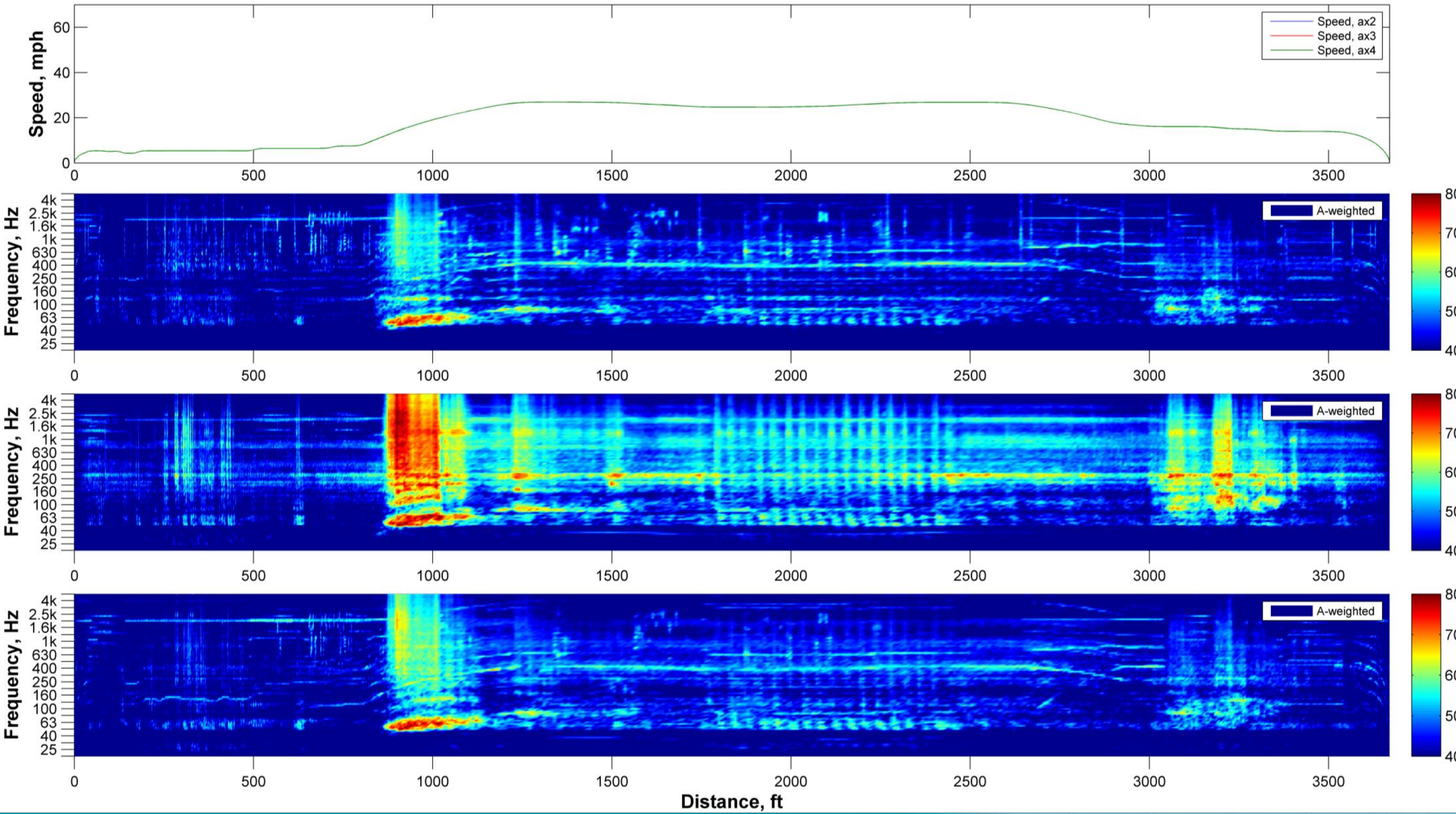
On-board Noise Measurement



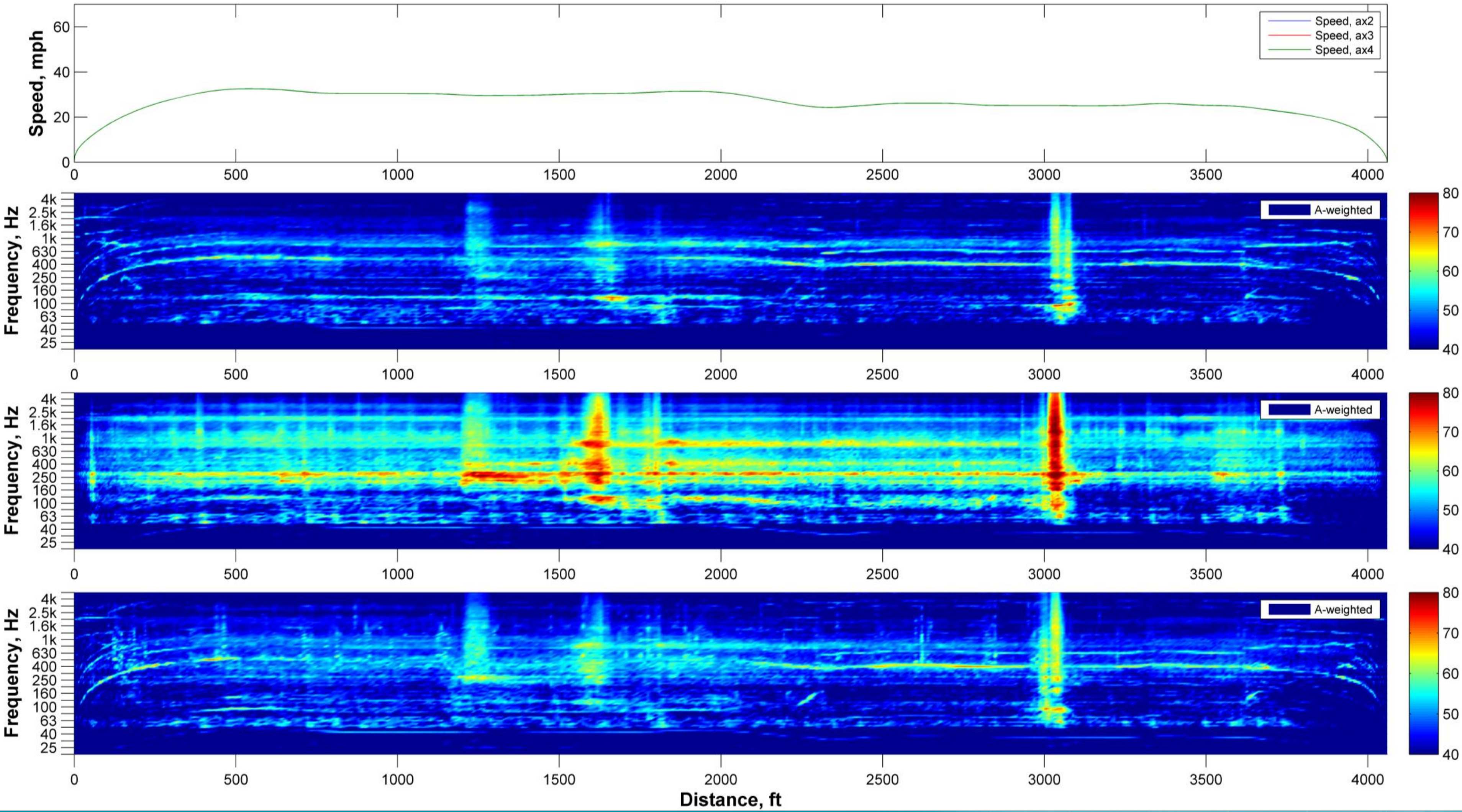
Example On-Board Spectrogram (1)



Example On-Board Spectrogram (2)

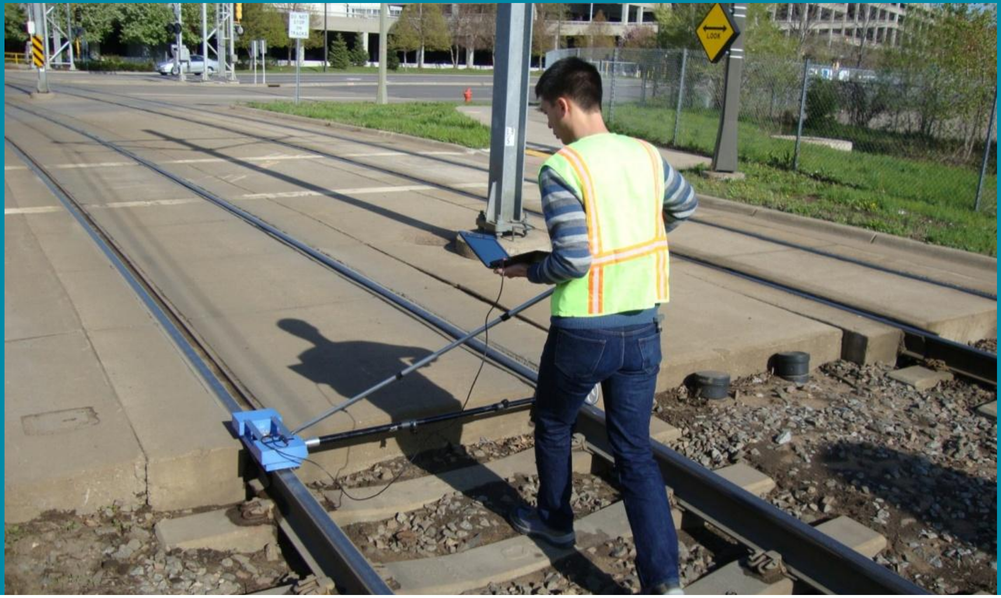


Example On-Board Spectrogram (3)

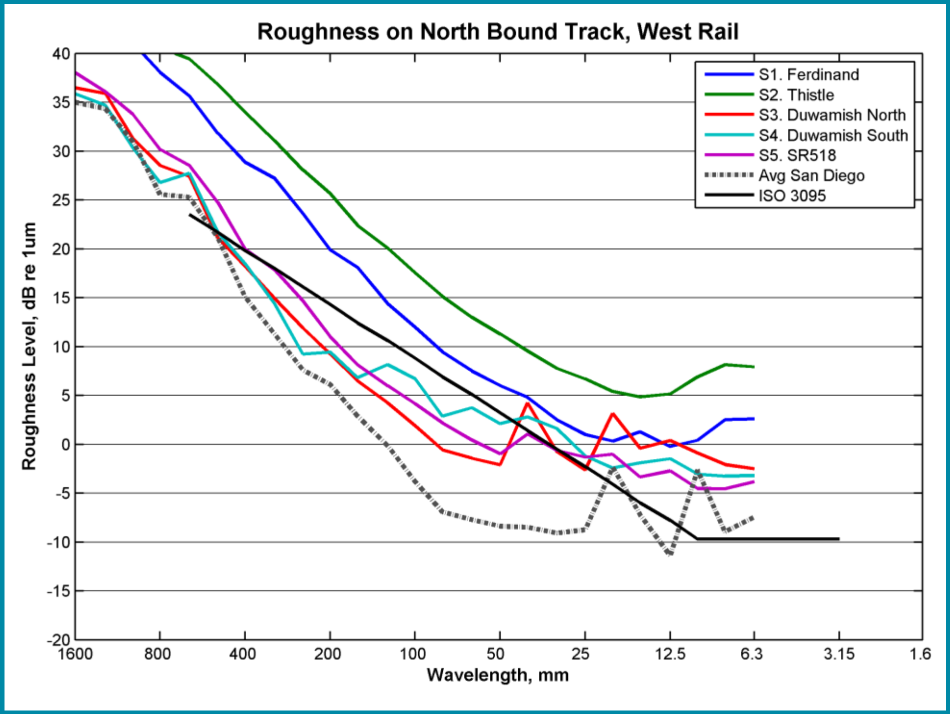


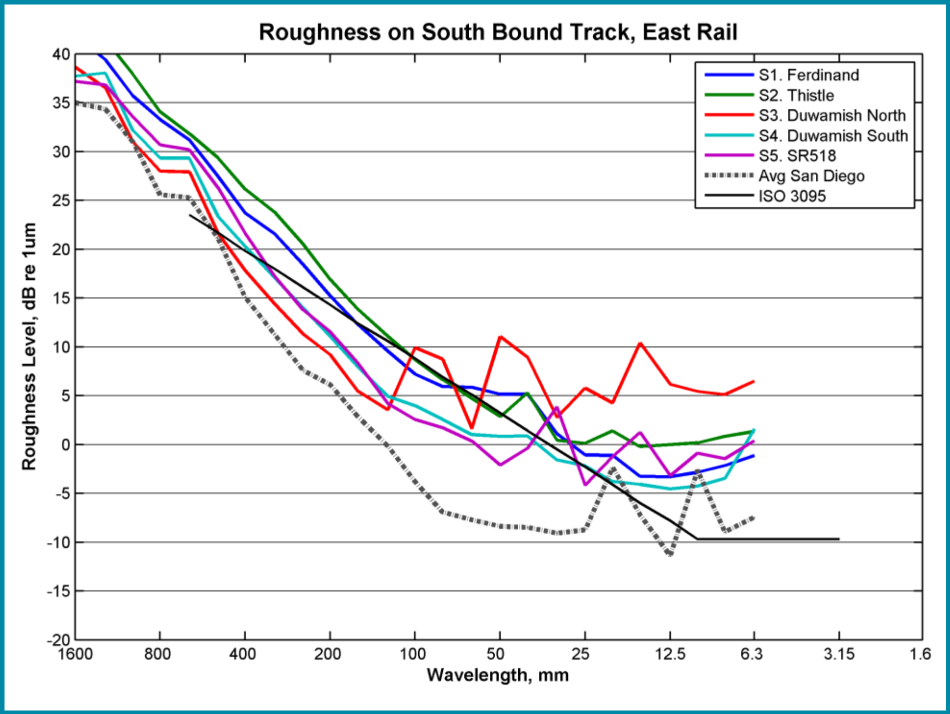
Rail Roughness Measurements

Measure vertical displacement in wear band over a small track section (typically 100 to 300m)

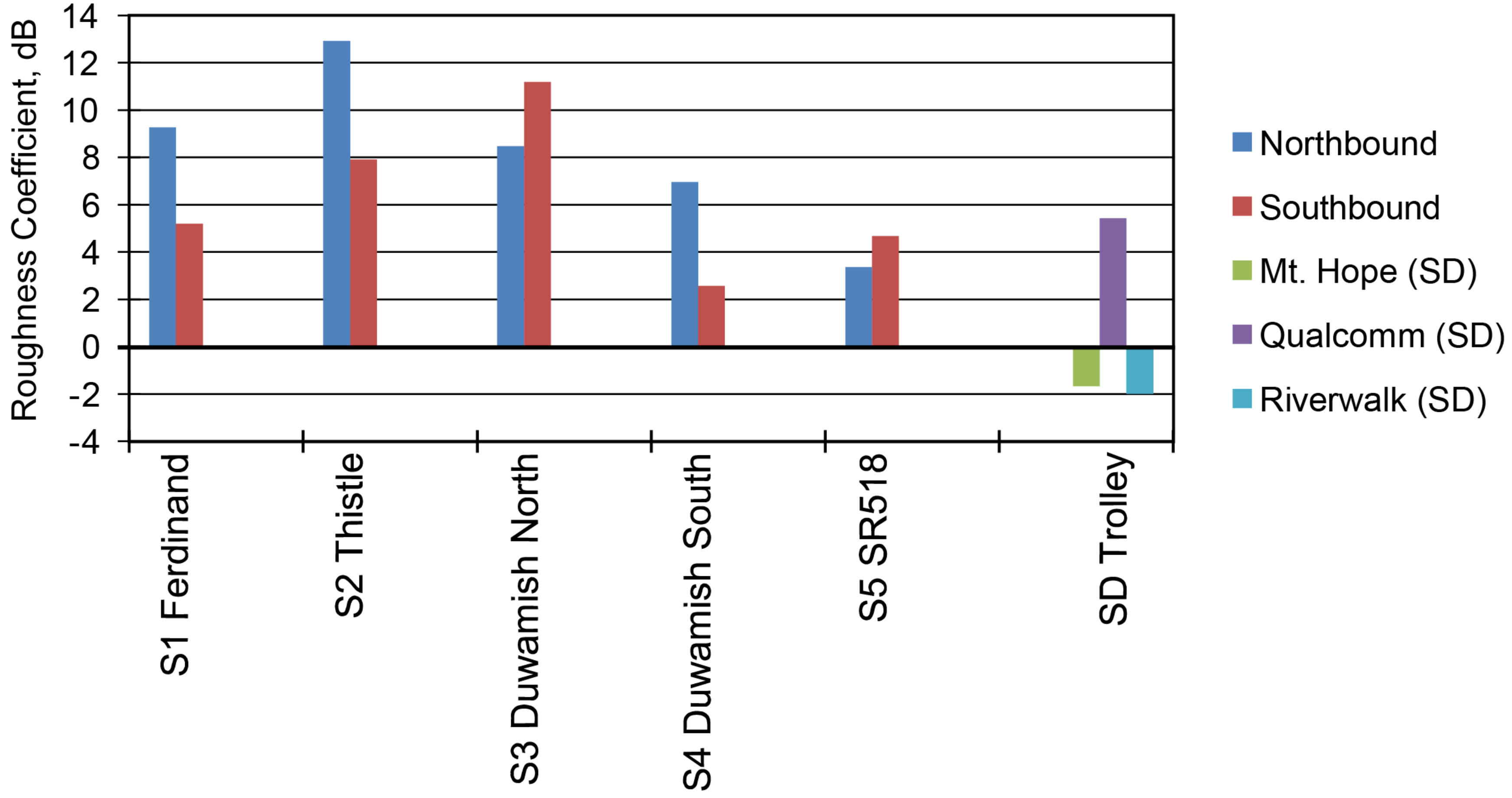


Average Roughness, 1/3 Octave Band Spectra

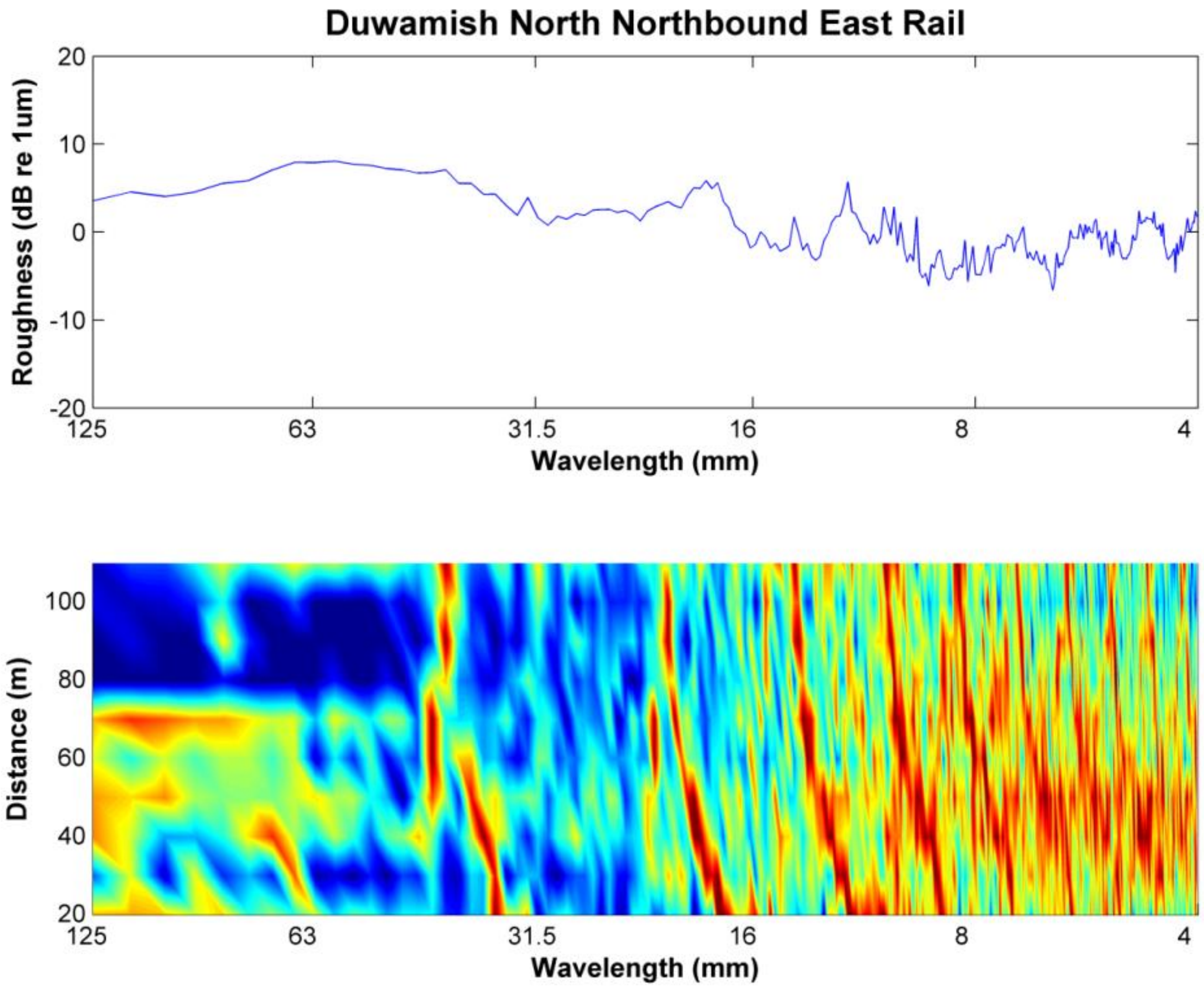




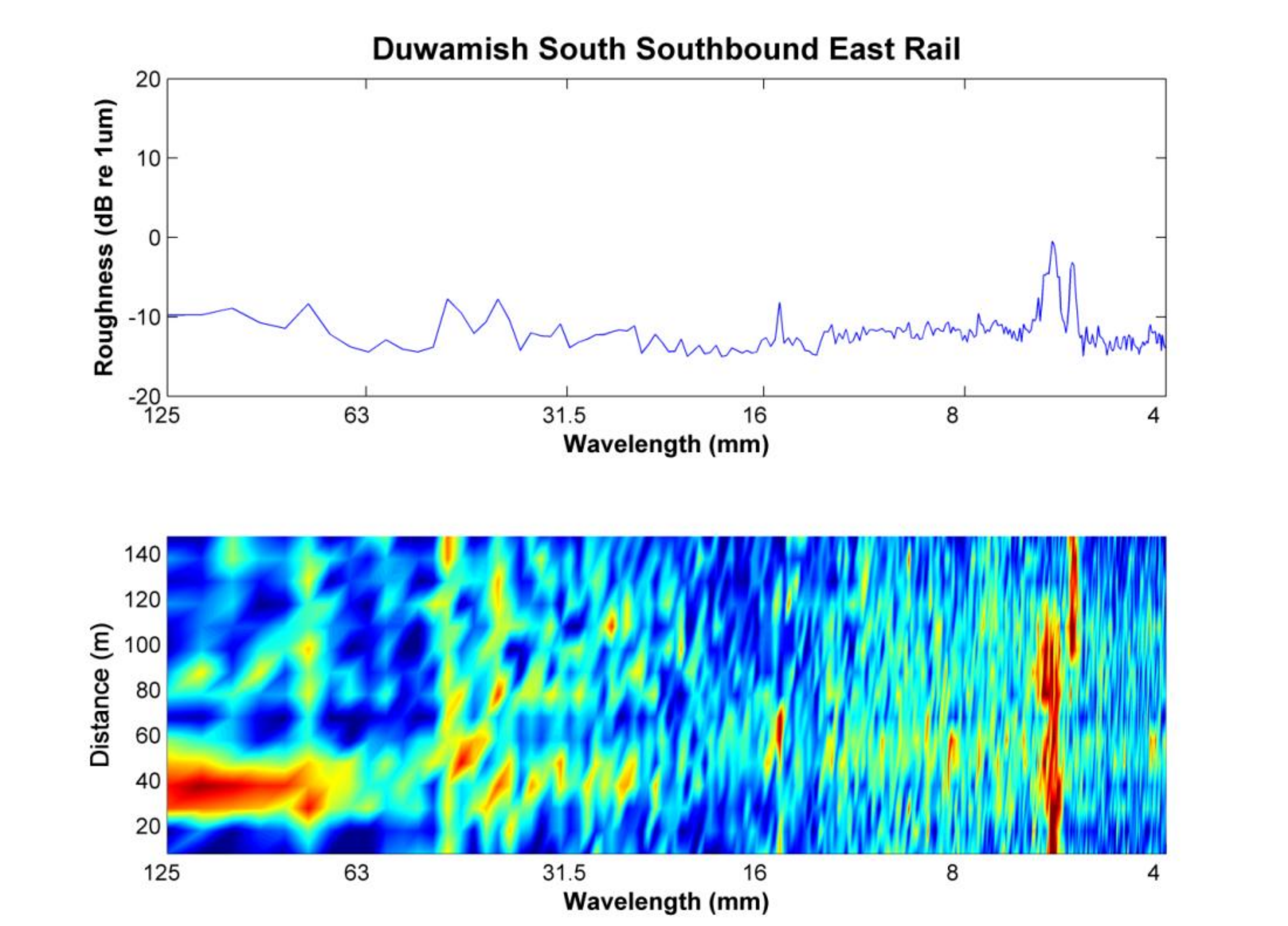
Derived Roughness "Coefficient"



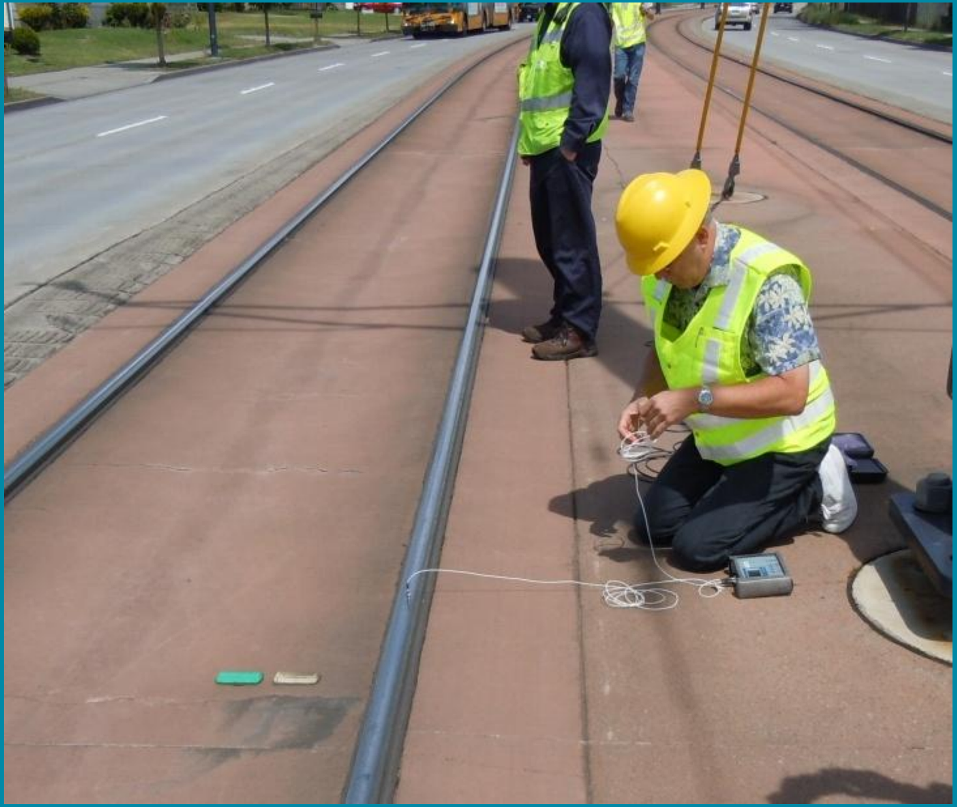
Roughness Spectrogram, Site 3



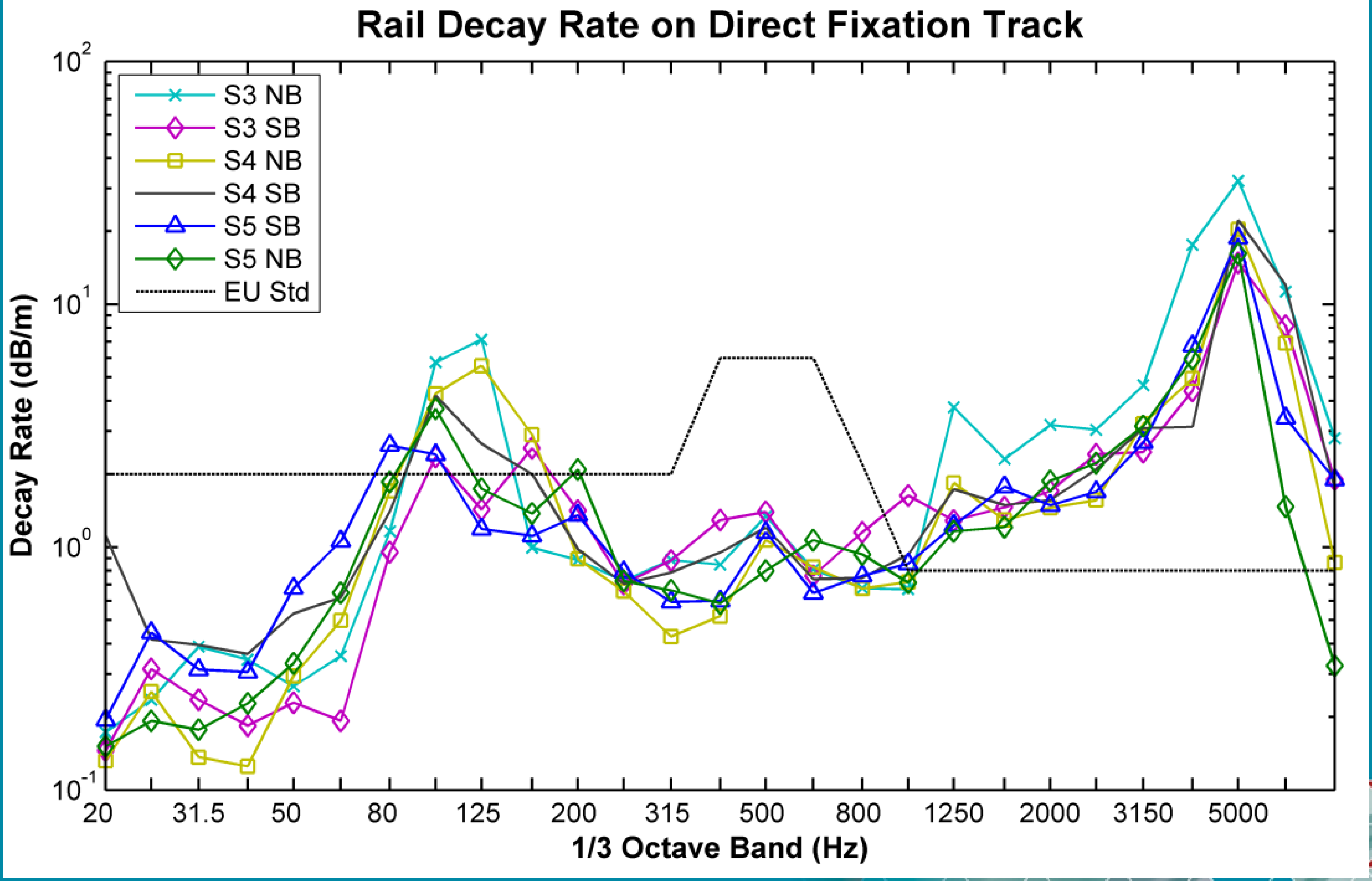
Roughness Spectrogram, Site 4



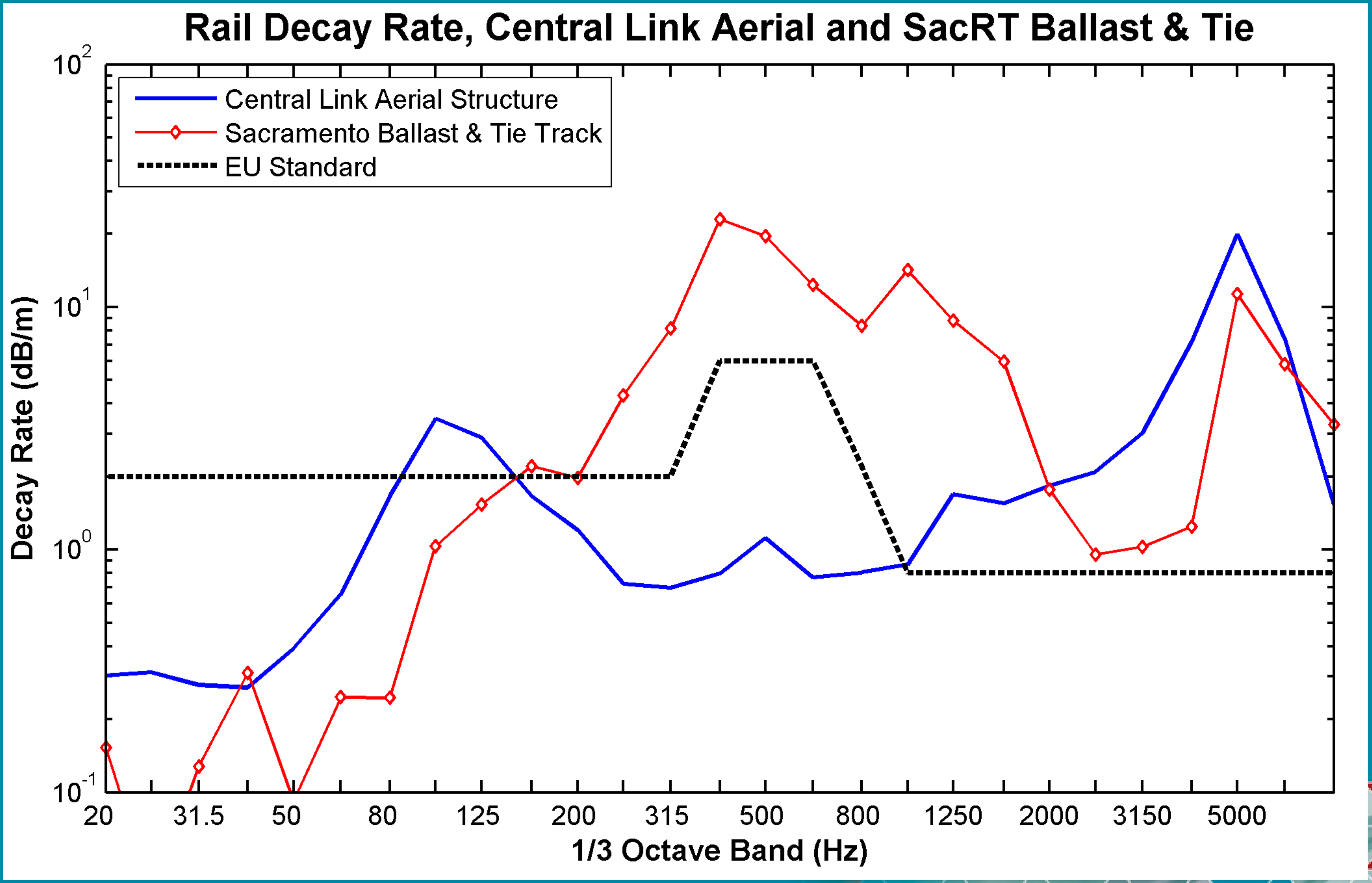
Vibration Decay Rate Measurement



Rail Vibration Decay Rate

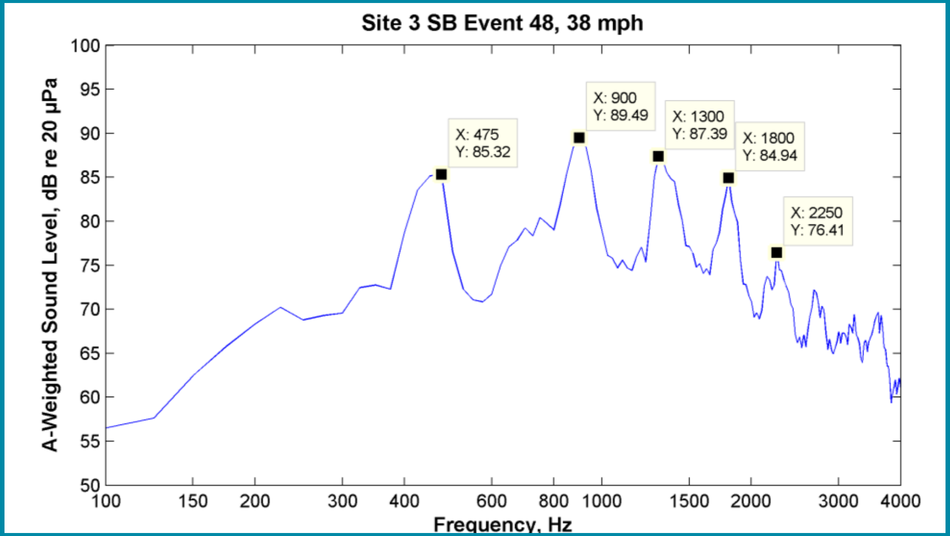


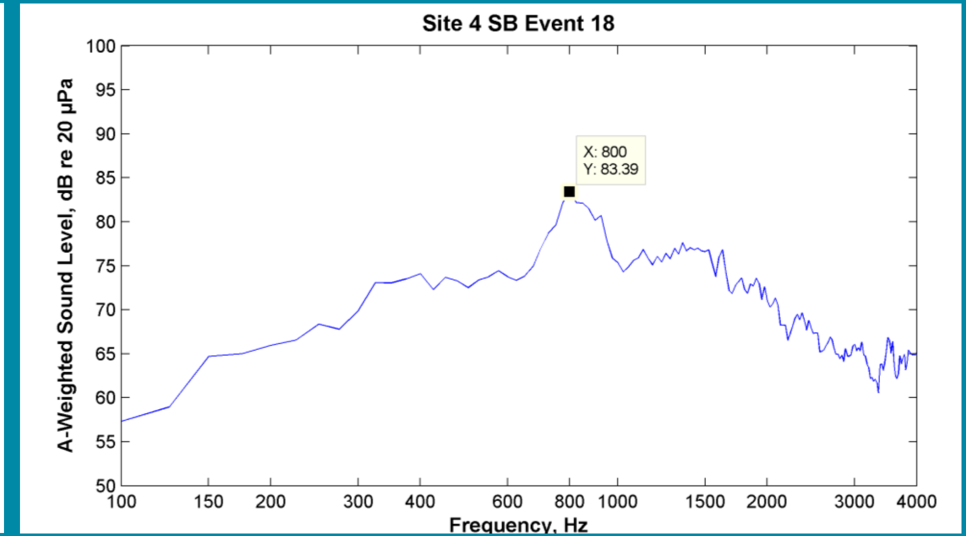
Average Rail Vibration Decay Rate



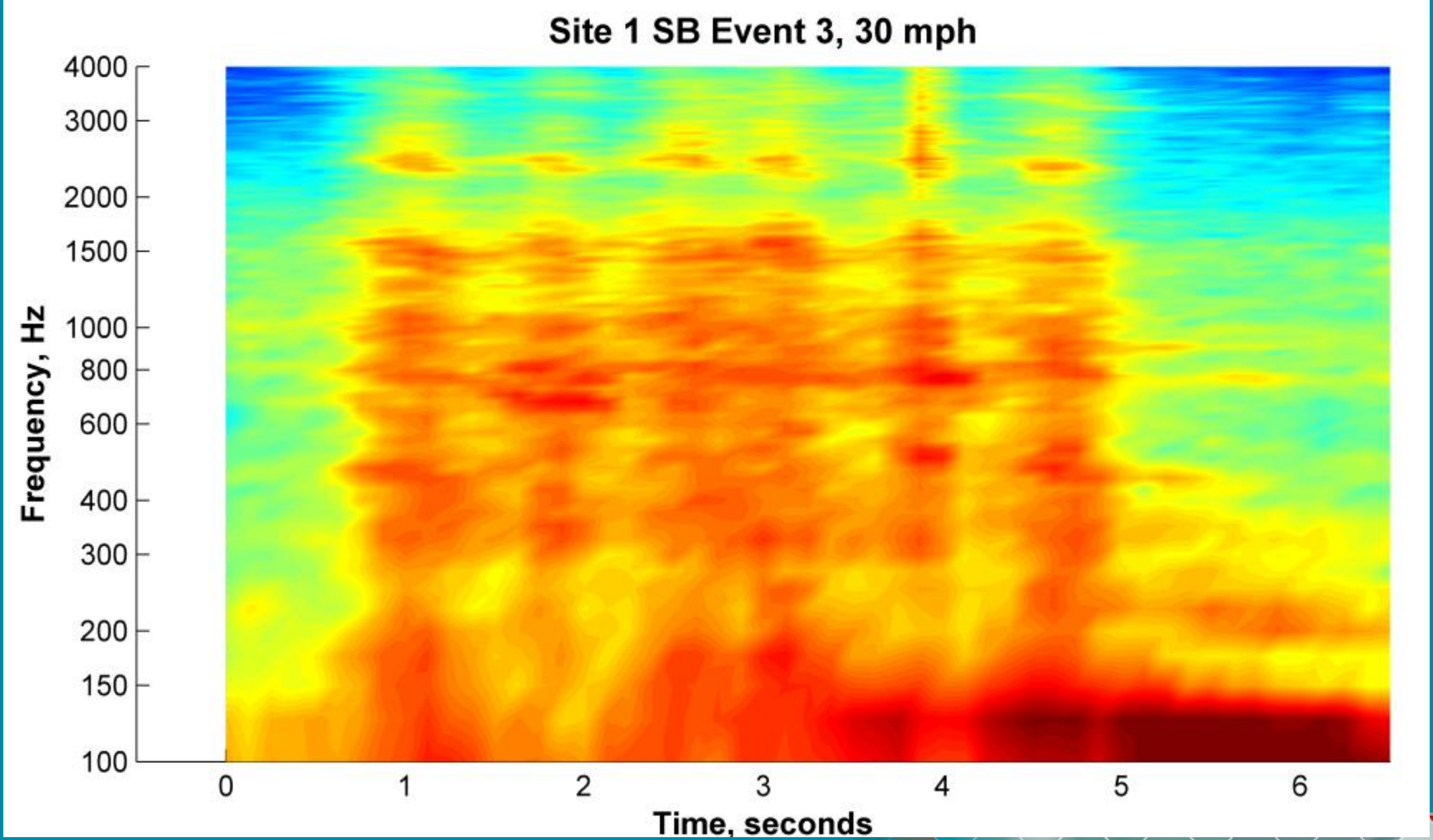
Noise Measurements 1m from Rail

Typical Noise Spectra, Site 3 and Site 4





Is Noise from Wheel or Rail?



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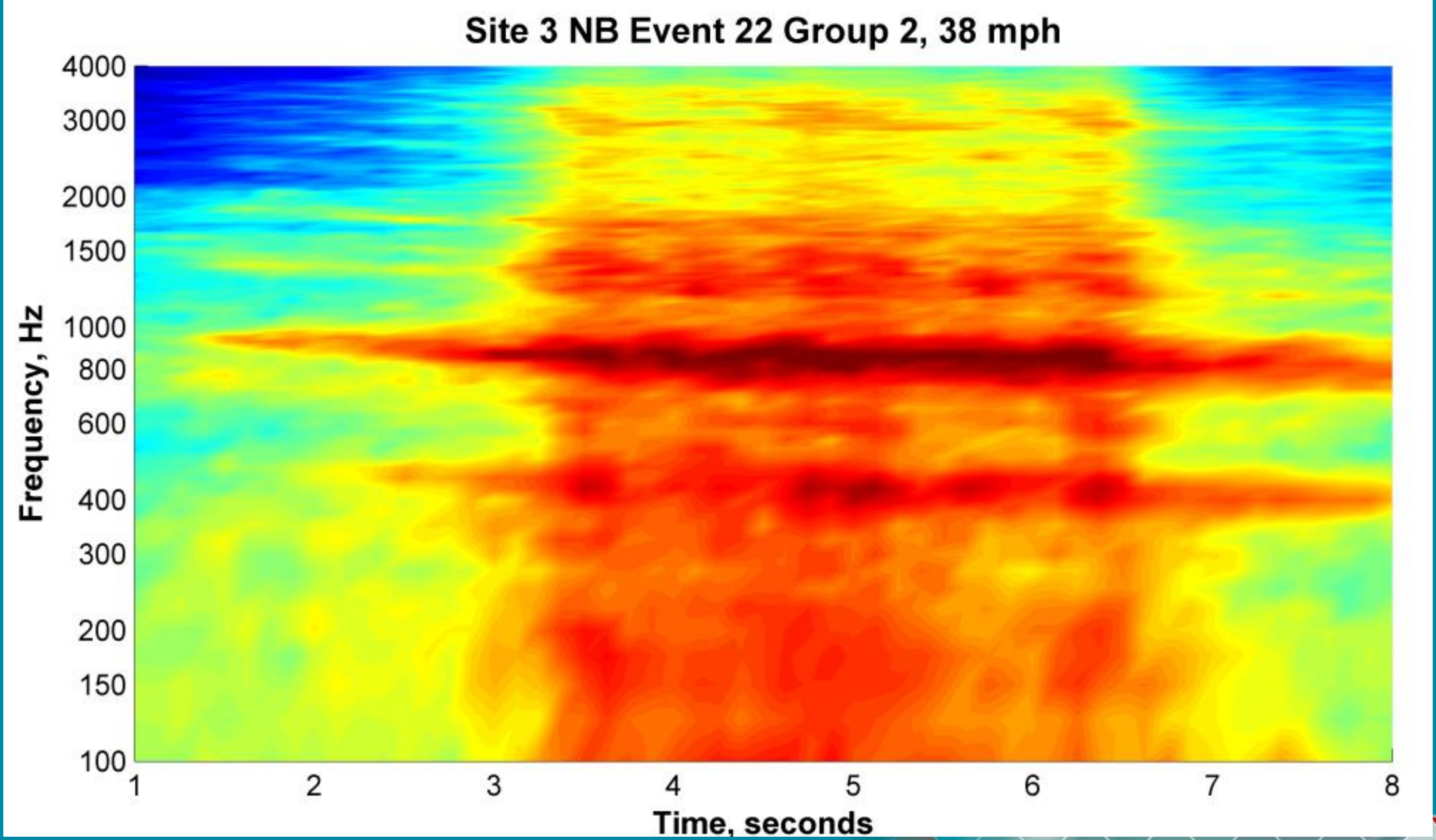
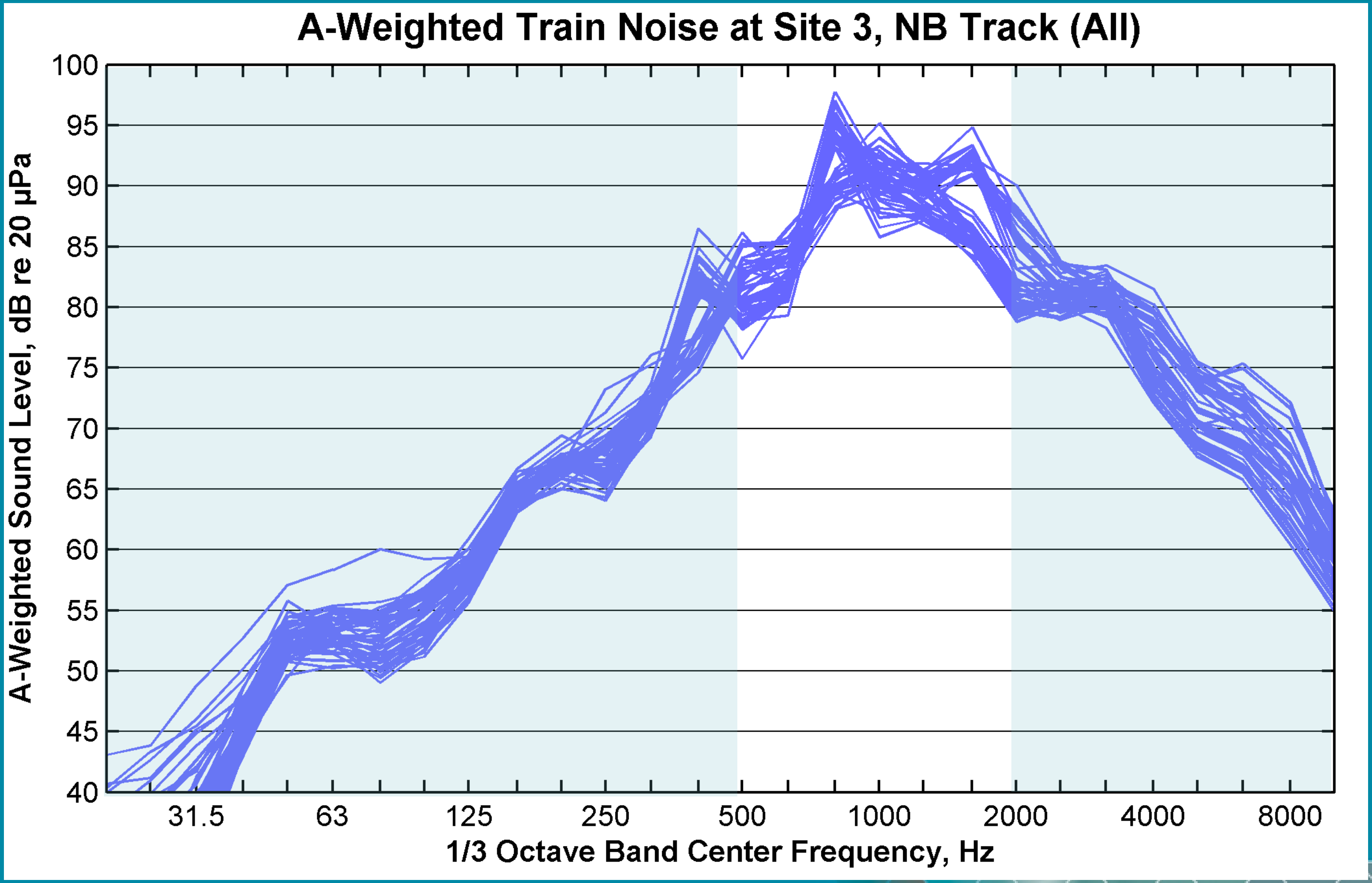


Conclusion:

- Embedded track noise is dominated by wheel
- Aerial structure noise is dominated by rail vibration
- This result along with rail decay rate suggests that rail dampers would be effective at reducing noise on aerial structure

All Trains, at Site 3, Duwamish NB
(Sound Transit)



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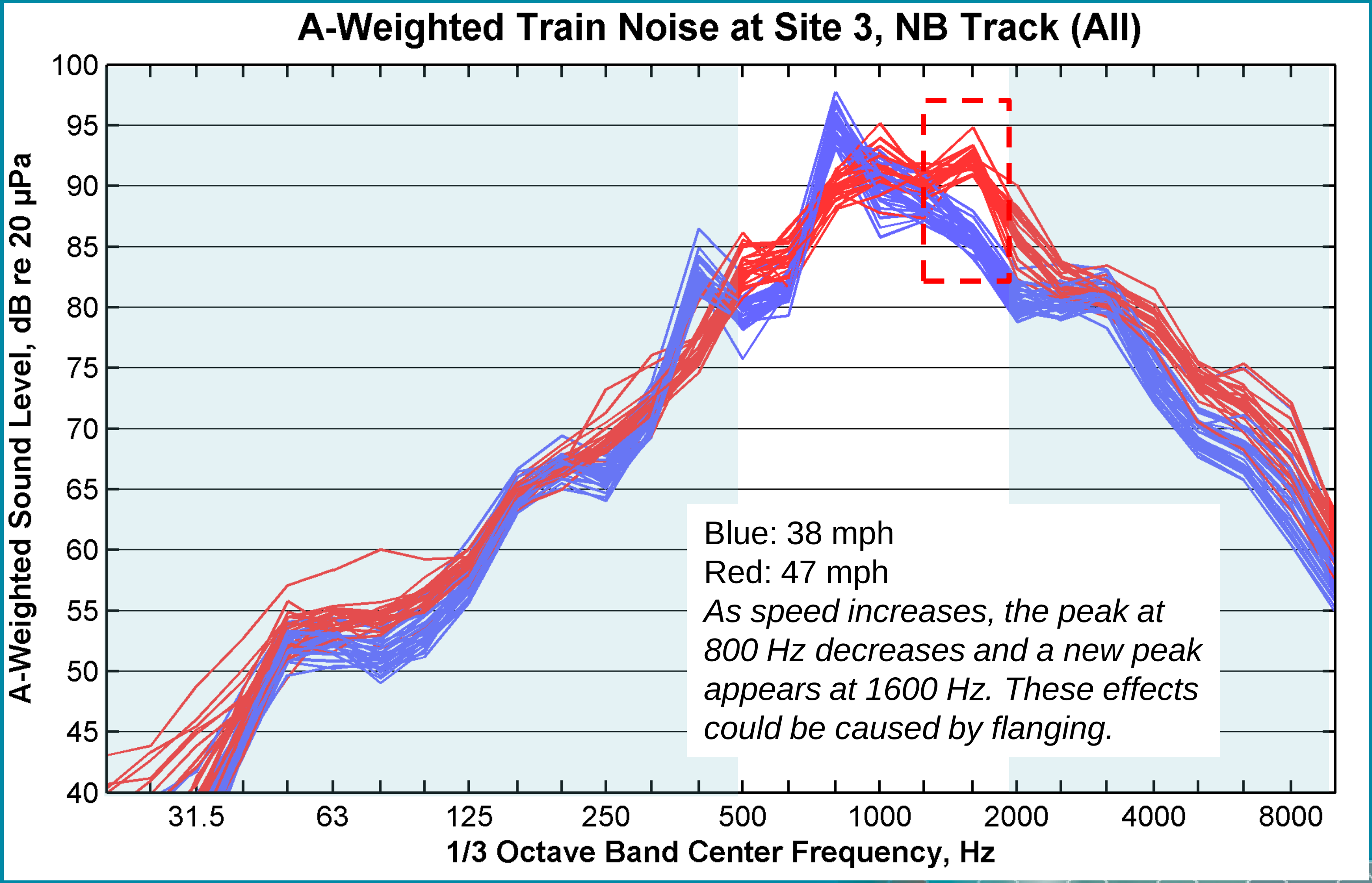
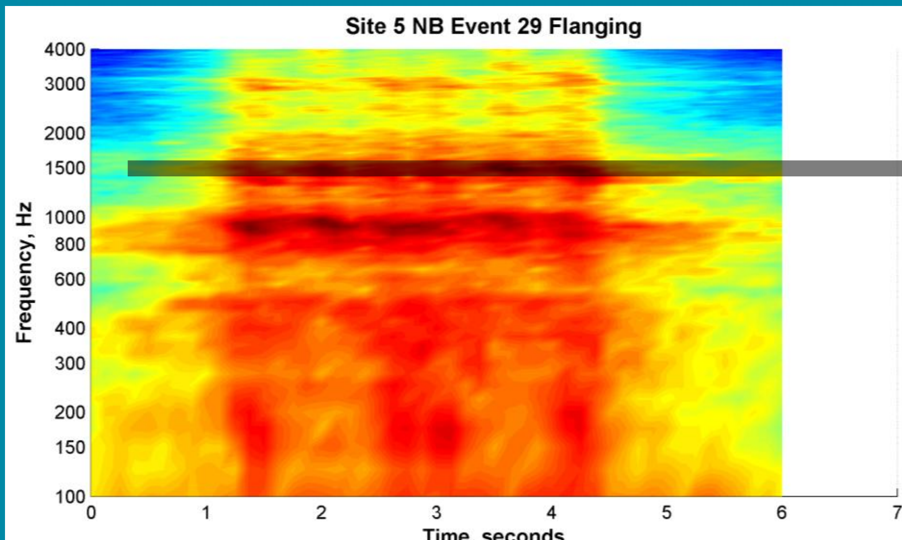
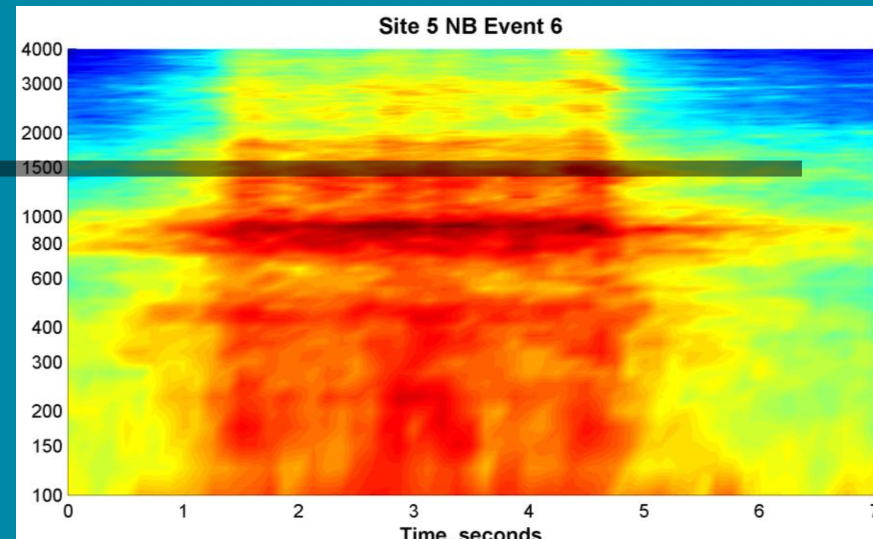
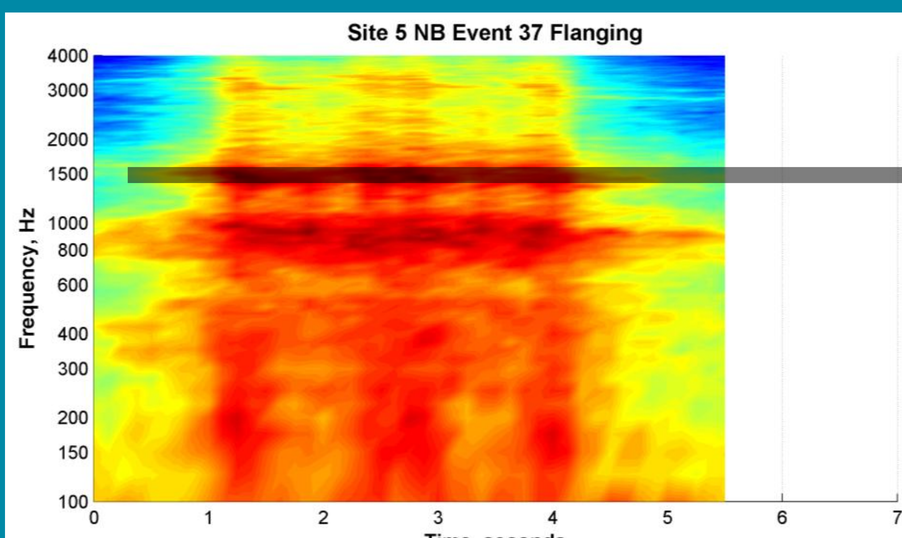
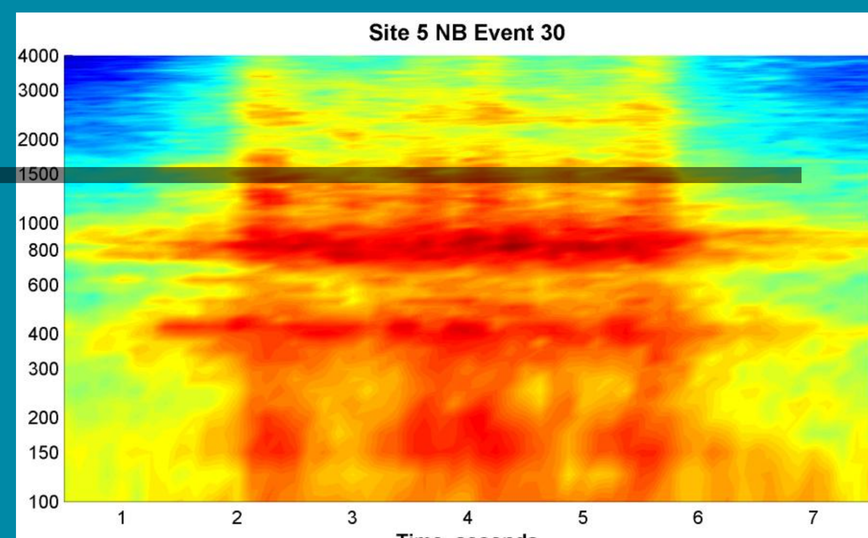


Example Noise Spectrograms, Sit 5







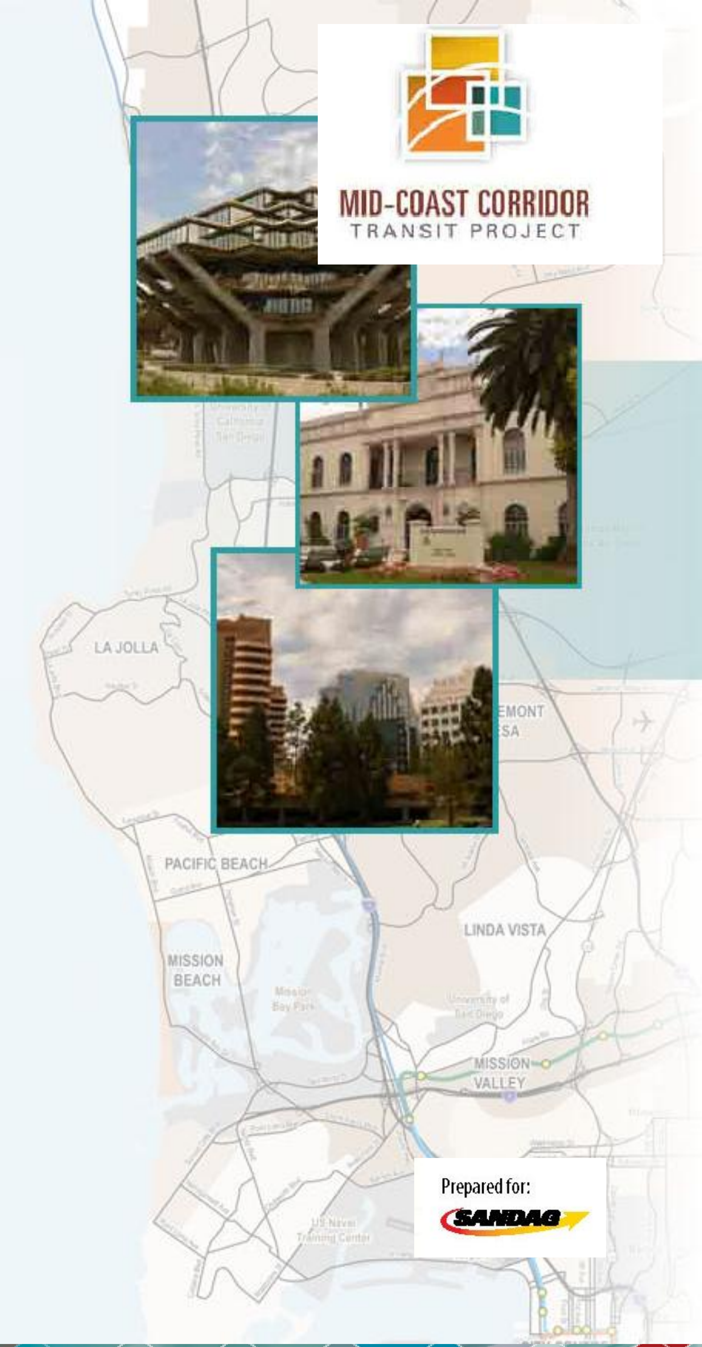


CONCLUSIONS

- Low noise requires smooth wheels and track
- Future rail grinding should meet roughness tolerances (Suggest ISO 3085 limits as starting point)
- All noise sources that must be addressed to achieve maximum noise reduction
- Rail and wheel dampers are a potential noise mitigation measure

Example,
San Diego Trolley

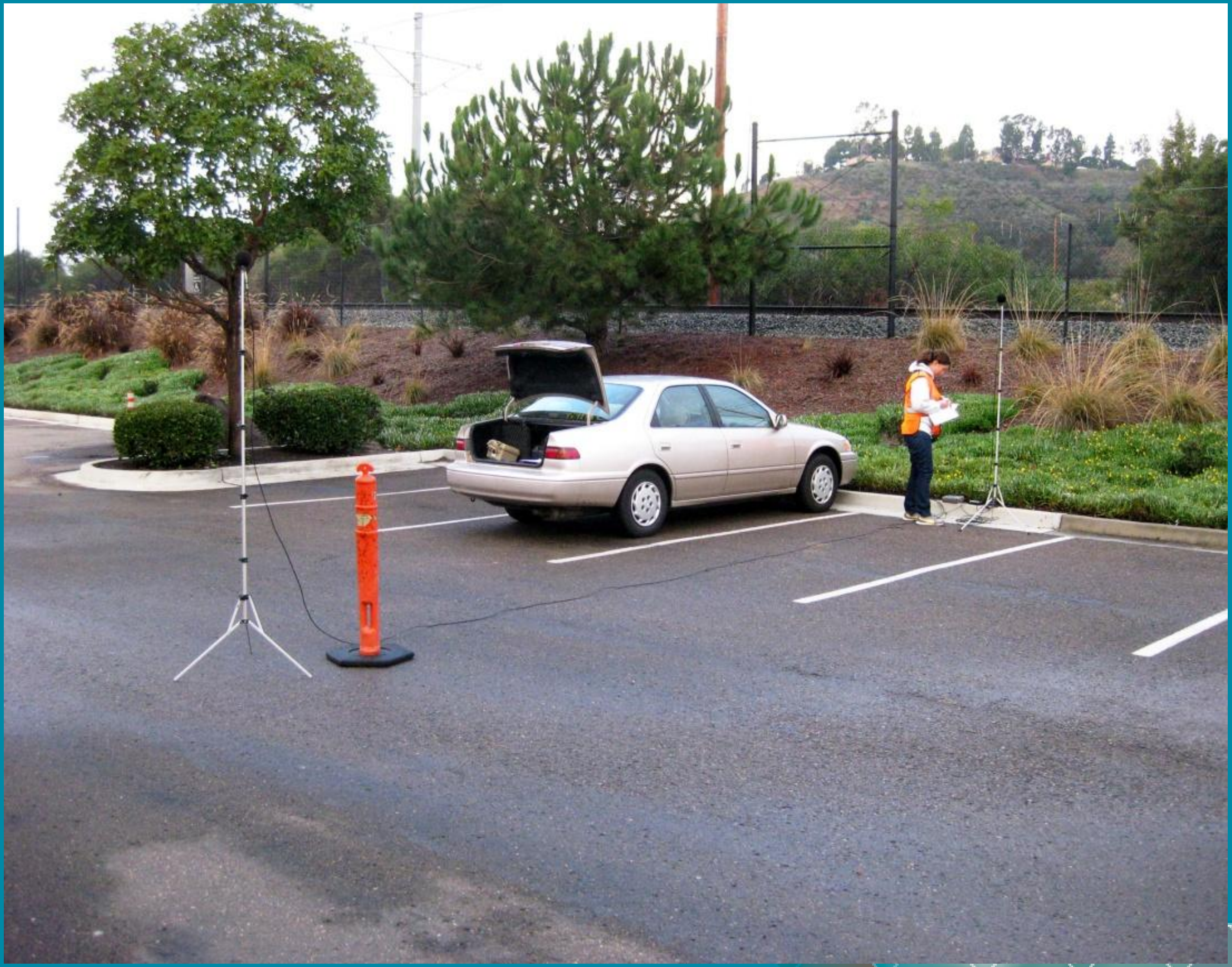
- Environmental studies for Mid-Coast Corridor
- 11 Mile extension to San Diego Trolley from Old Town to University City
- Originally studied in early ‘90s.
- Projected:
  - Start of Construction: 2015
  - Operations: 2018



Noise Testing for Environmental Assessment

- Four locations, three ballast & tie, one aerial structure
- Three vehicle types
  - U2 and SD100 (high floor)
  - S70 (low floor)
  - US-S70 (low floor)
- Measurements:
  - Wayside noise
  - Train speed
  - Rail roughness

Site 2: Riverwalk Golf Course



Final Results

Site	Track Type	Lmax, dBA	
		S70/US-70	SD100
1	Ballast & Tie	--	77
2	Ballast & Tie	74	--
3	Ballast & Tie	73	75
4	Aerial, Direct Fixation	76	77

Values normalized to 40 mph, 50 ft from track centerline, and 2-car trains.

FTA suggested reference level: 77 dBA, 40 mph, 50 ft, single car, ballast & tie track.

Equivalent levels on other LRT systems as high as 85 dBA.

Bottom Line

- Justified using a reference level of 75 dBA
- 2 dB lower than FTA recommendation
- Substantially lower than recently measured on similar LRT systems.
- Amount of noise mitigation (sound walls) substantially reduced.
- Lower reference level might be reasonable.