Rail Clip Failure Investigation at Sound Transit

Thomas Bergen

James T. Nelson

Wilson Ihrig

Hugh Saurenman

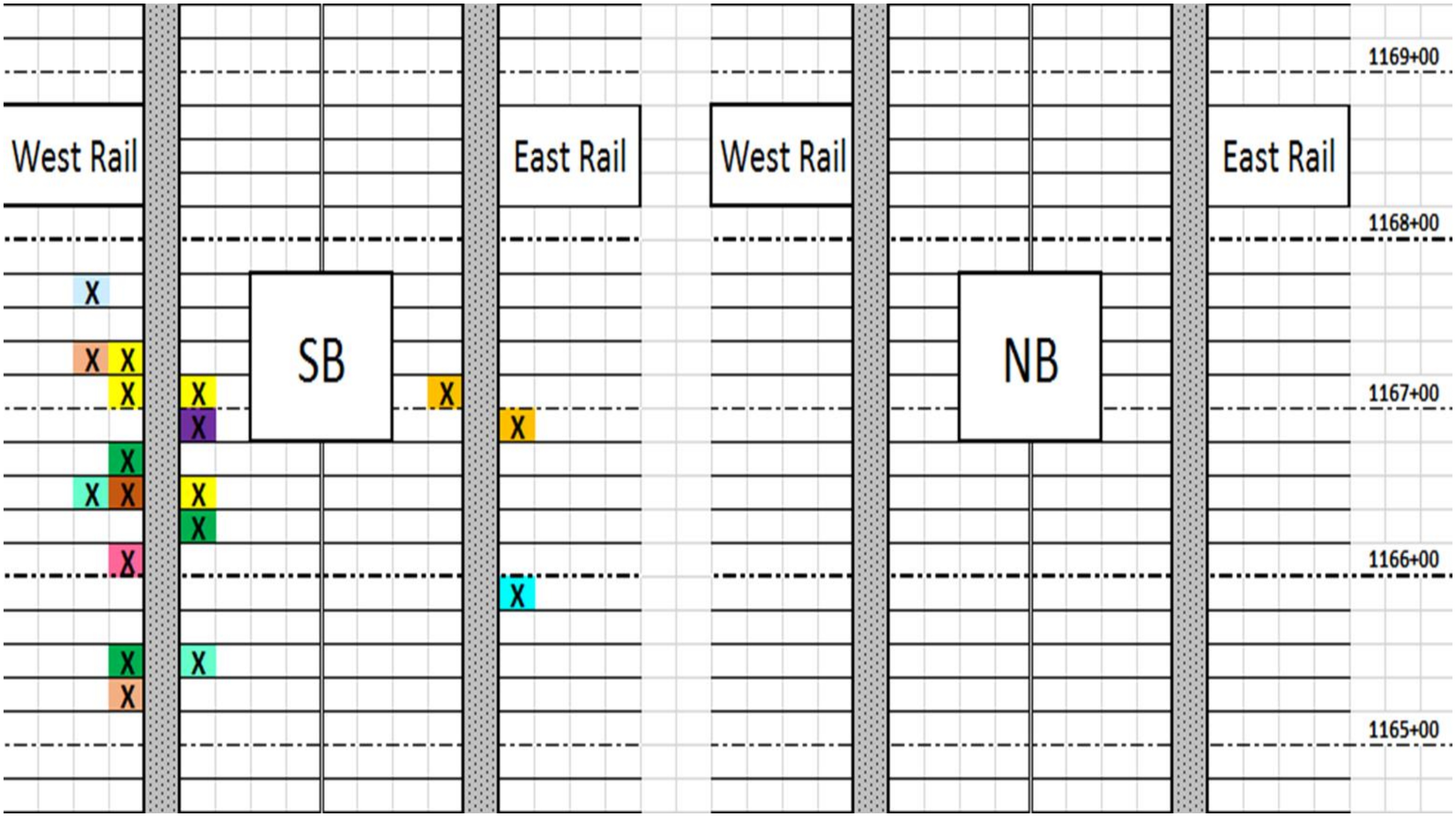
ATS Consulting

U-Link Extension Opens March 2016

Clip Failures – As of April 11, 2017

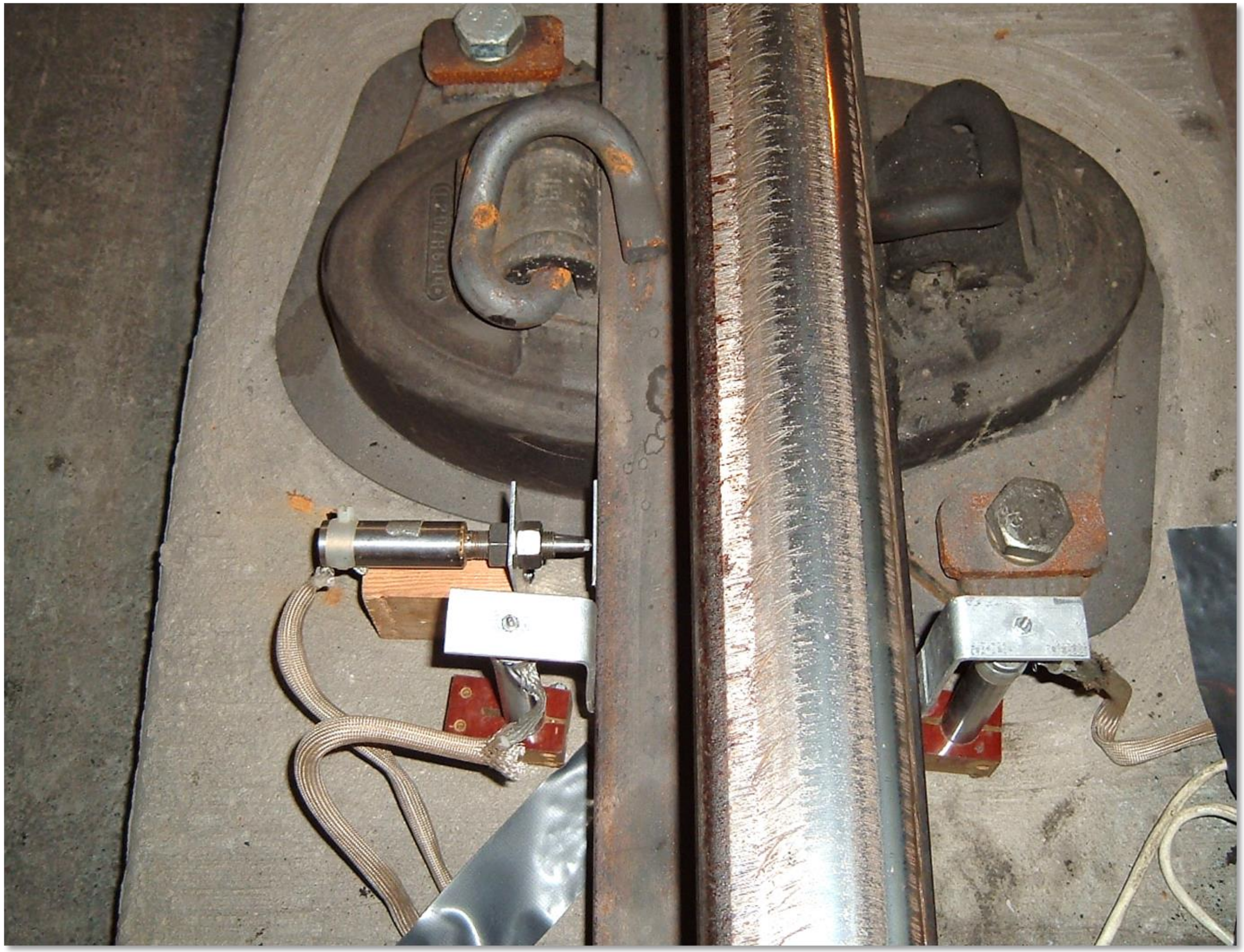
	North Bound Track				South Bound Track			
	East Rail		West Rail		East Rail		West Rail	
	Field Side	Gage Side	Field Side	Gage Side	Field Side	Gage Side	Field Side	Gage Side
GAUGE/FIELD	4	5	5	6	18	22	36	21
EAST/WEST	9		11		40		57	
NORTH/SOUTH	20				97			
TOTAL	**132**							

Map of Clip Failures

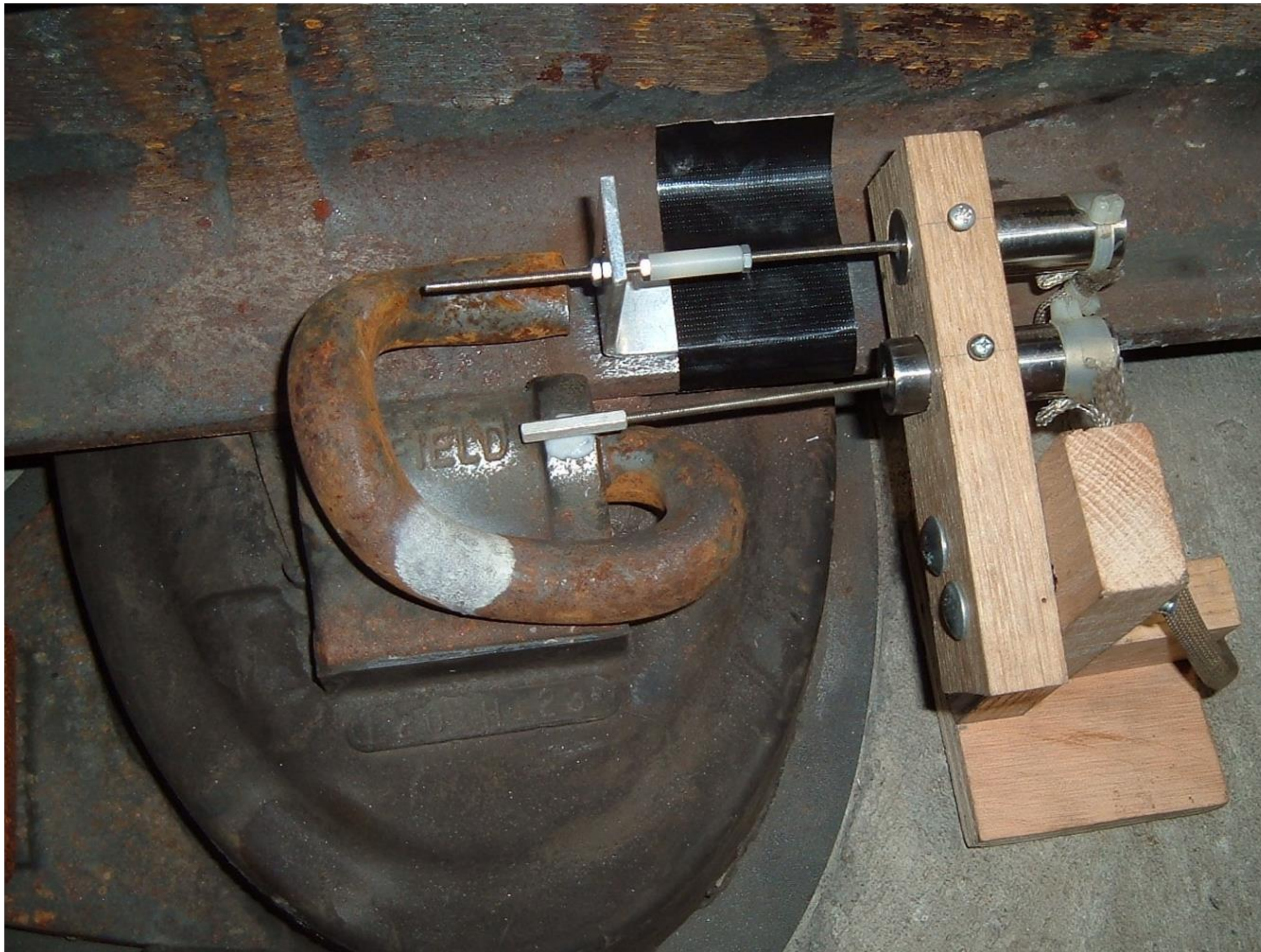


Clip Failure

Rail Deflection Measurement

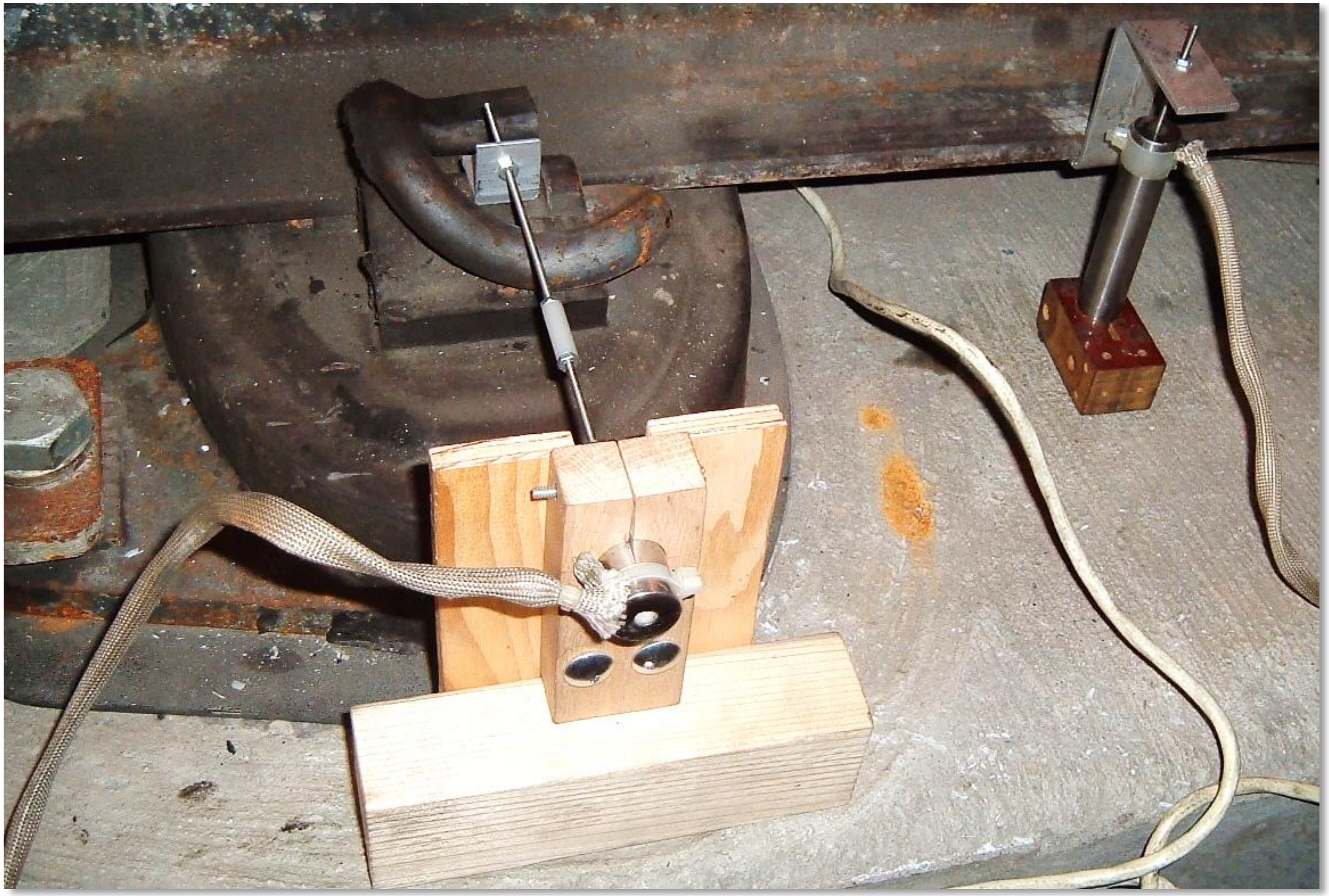


Longitudinal Deflection

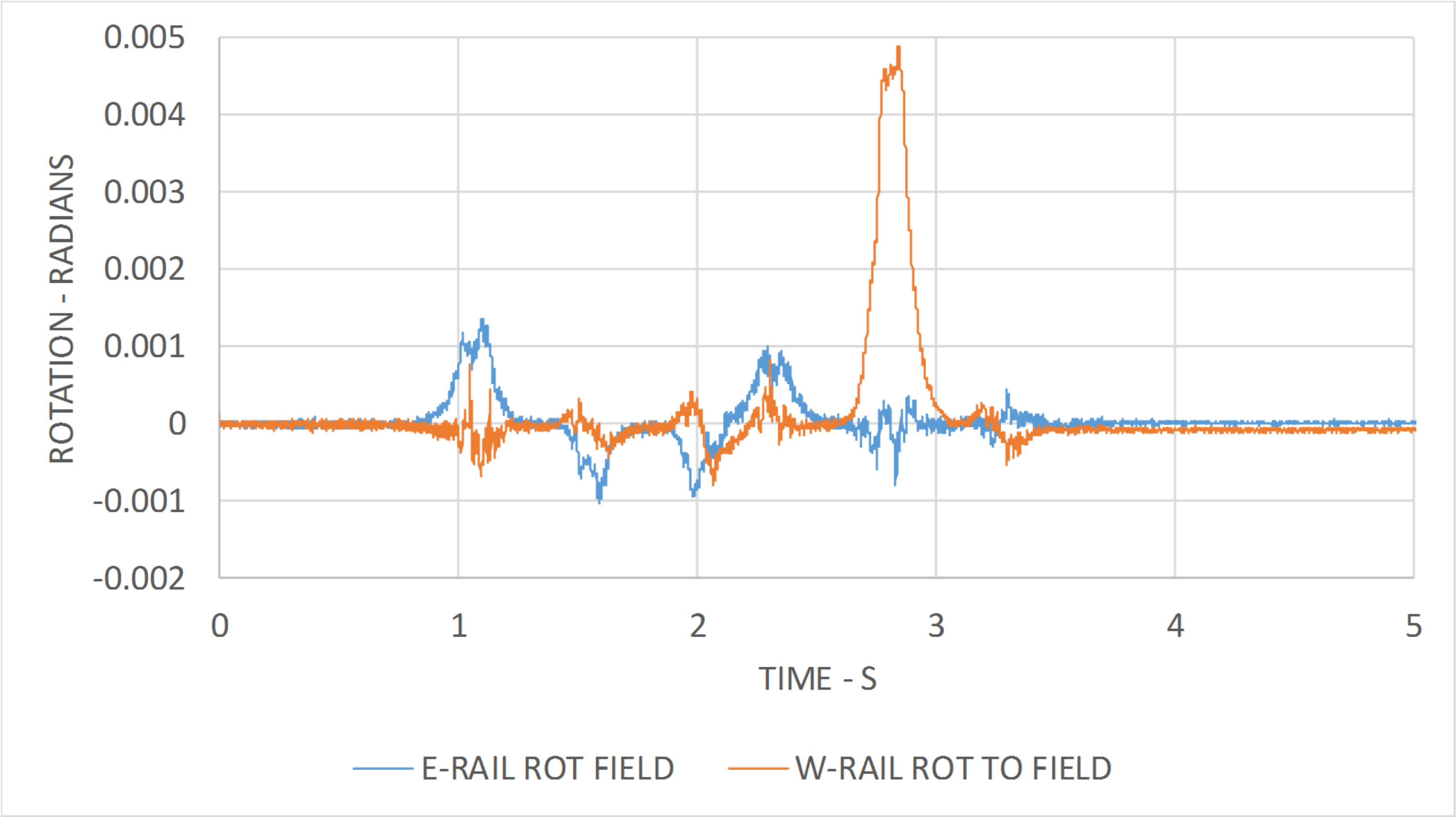


Top Plate Vertical Deflection and Rotation

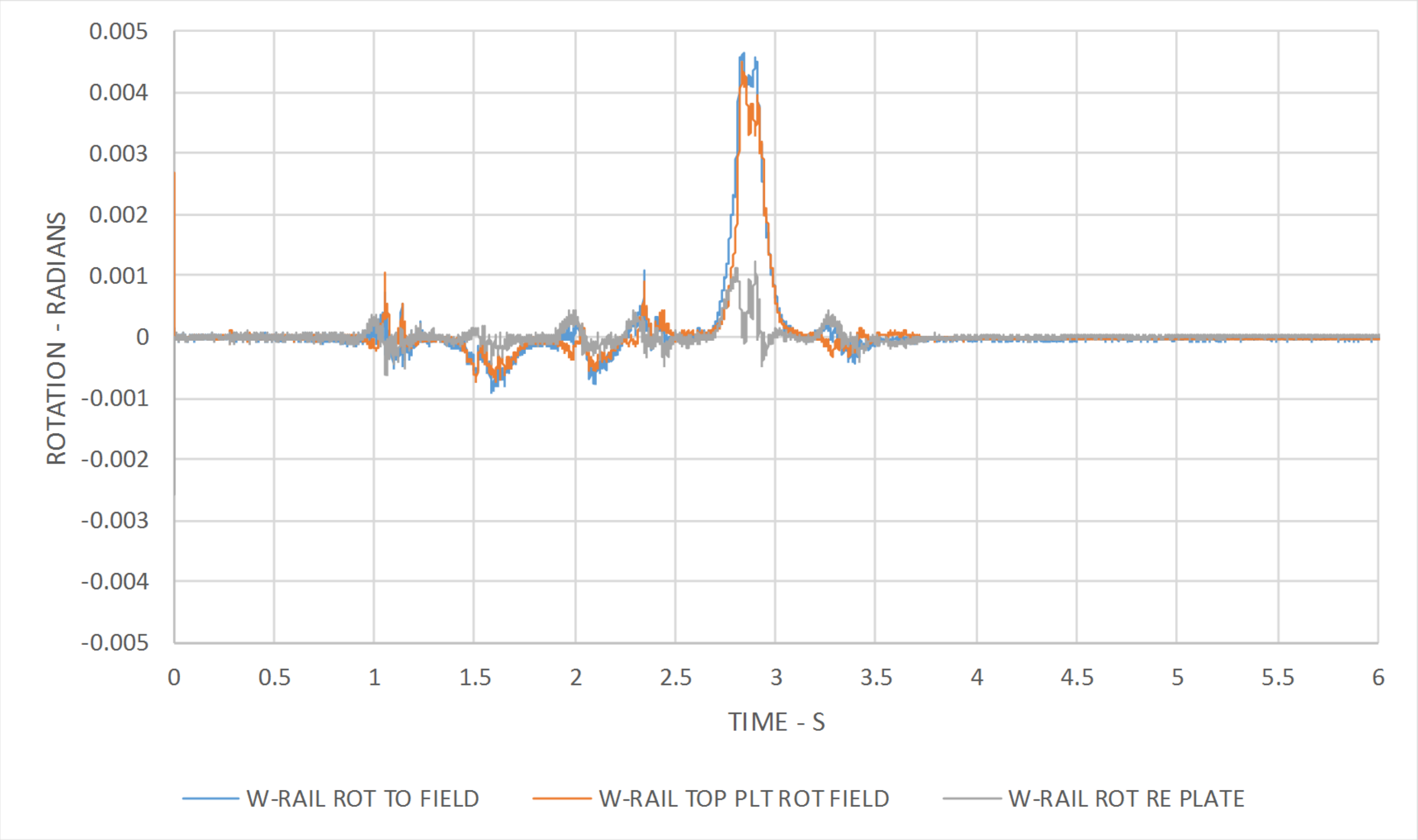
Top Plate Lateral



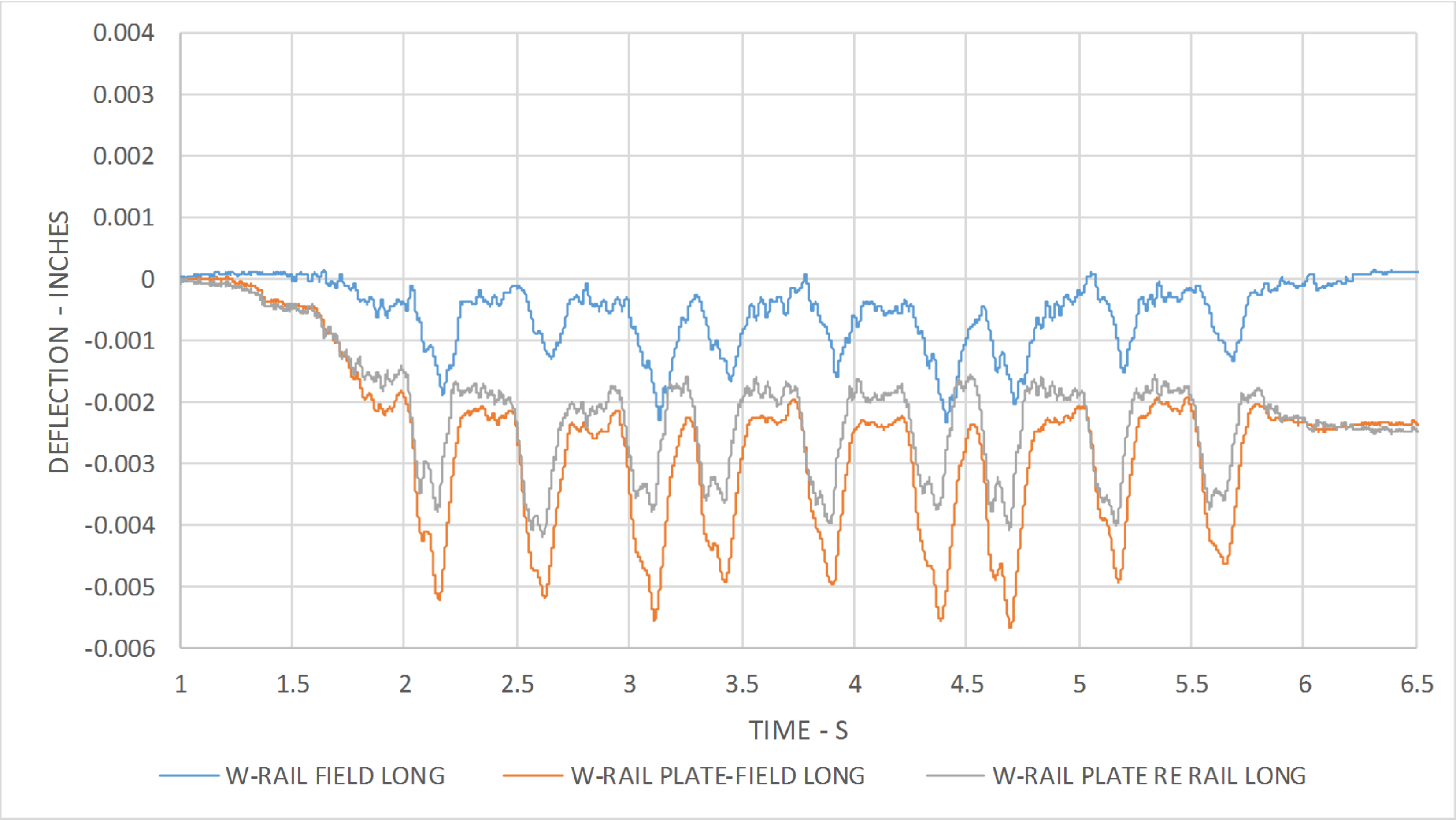
Southbound Track
Rail Rotation



Southbound West Rail and Fastener Top Plate Rotation

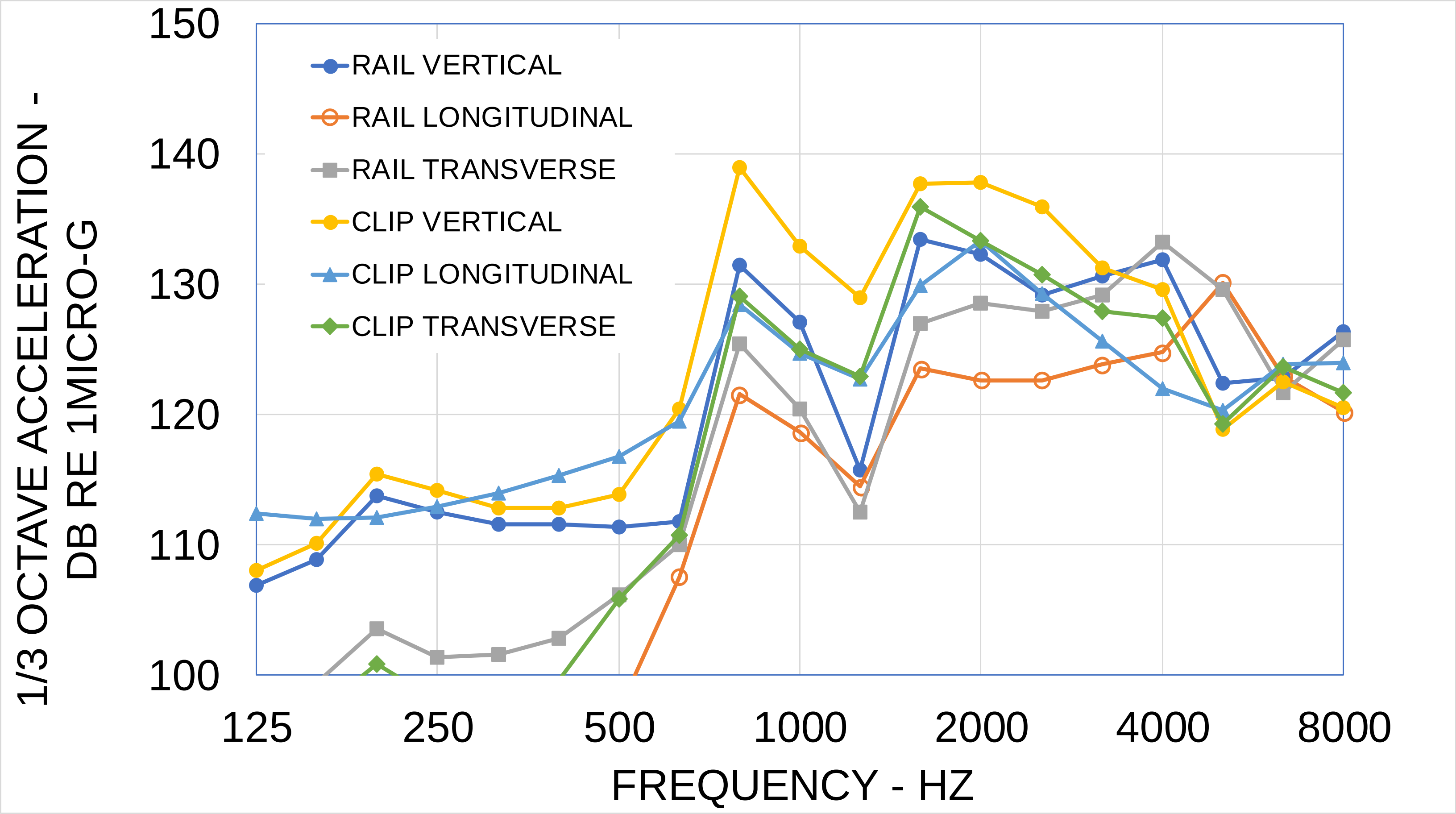


Longitudinal Deflection

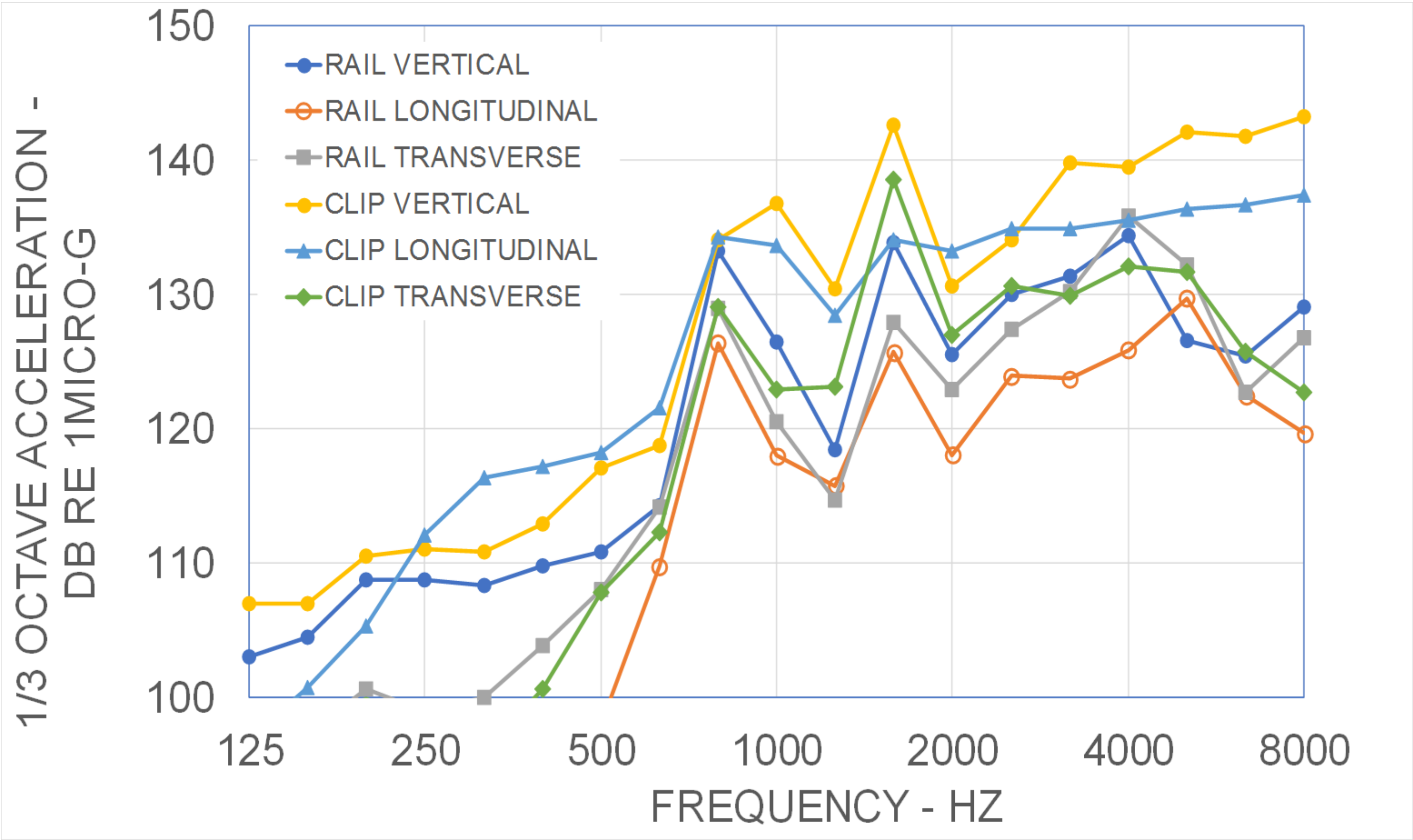


Accelerometers

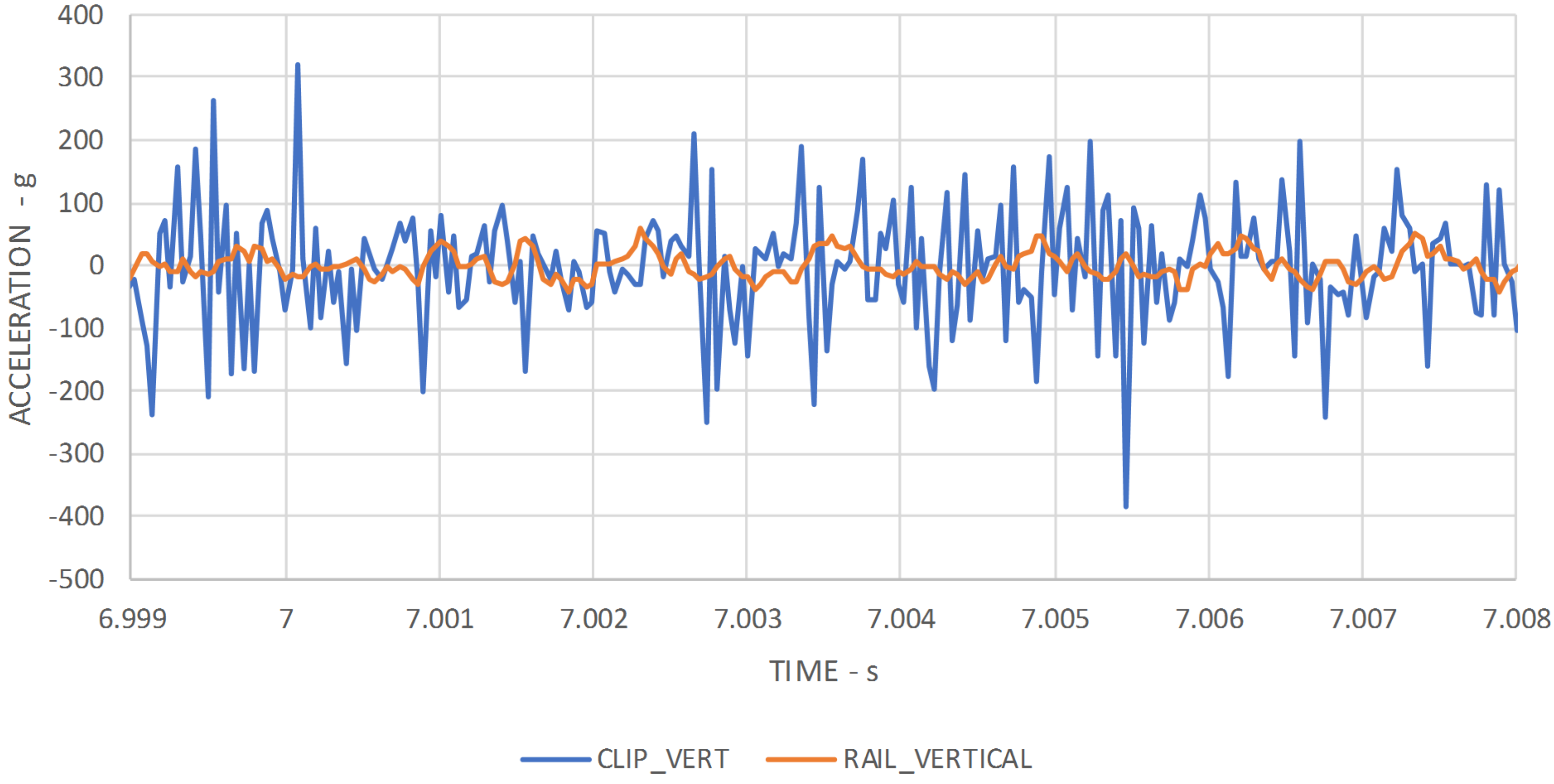
Acceleration Spectra – Northbound Track



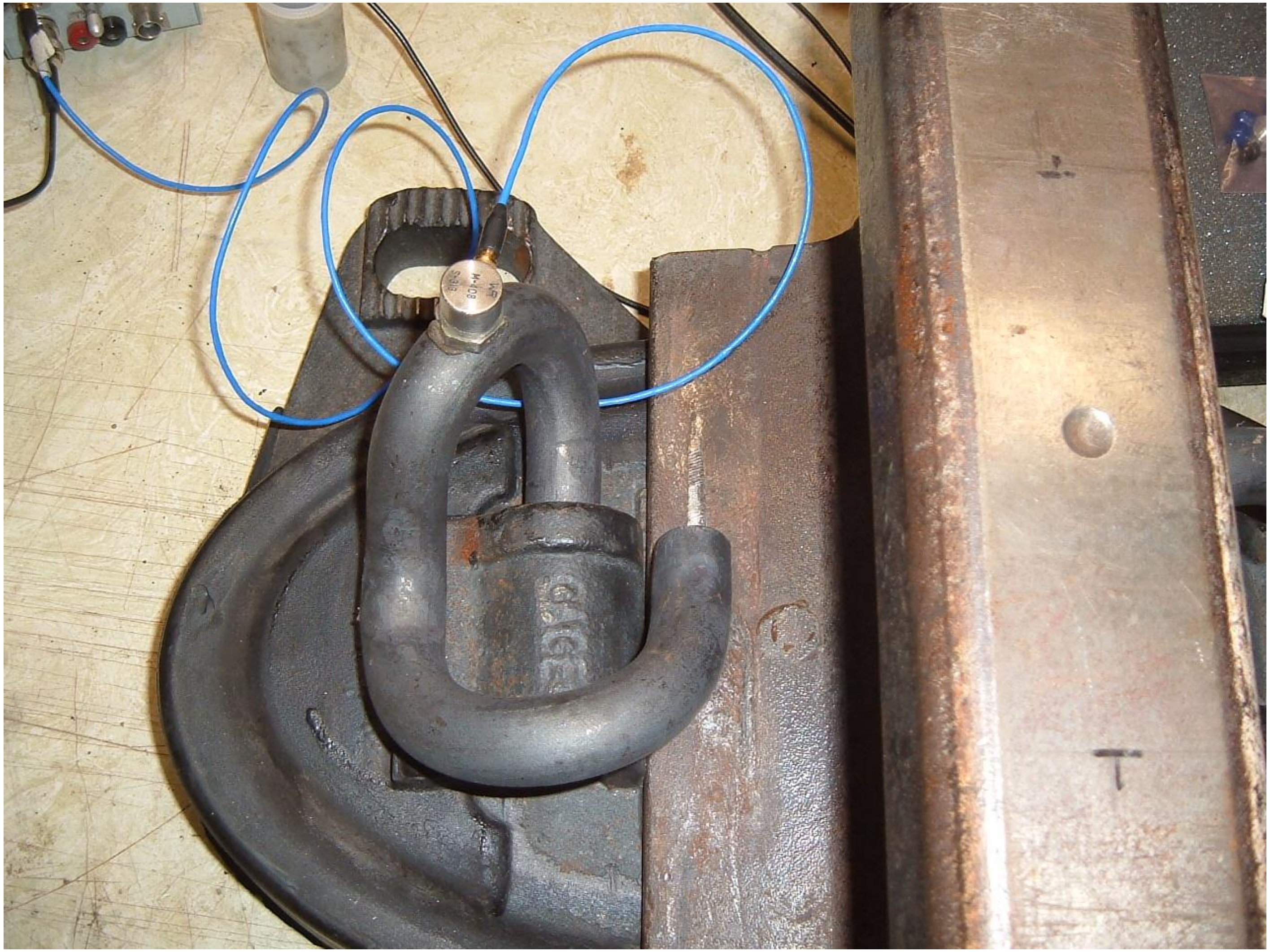
Acceleration Spectra – Southbound Track



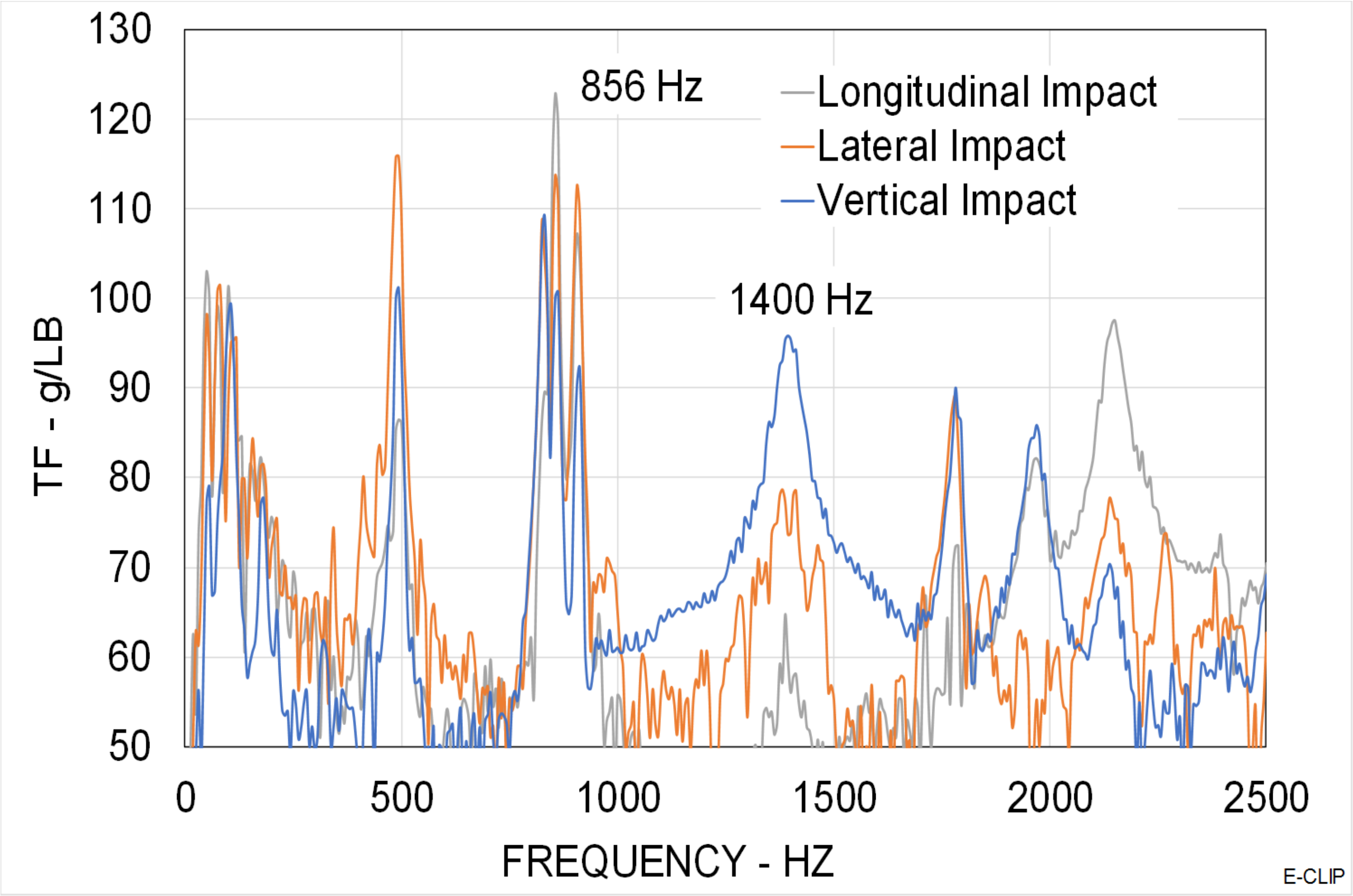
Broadband Vertical Acceleration



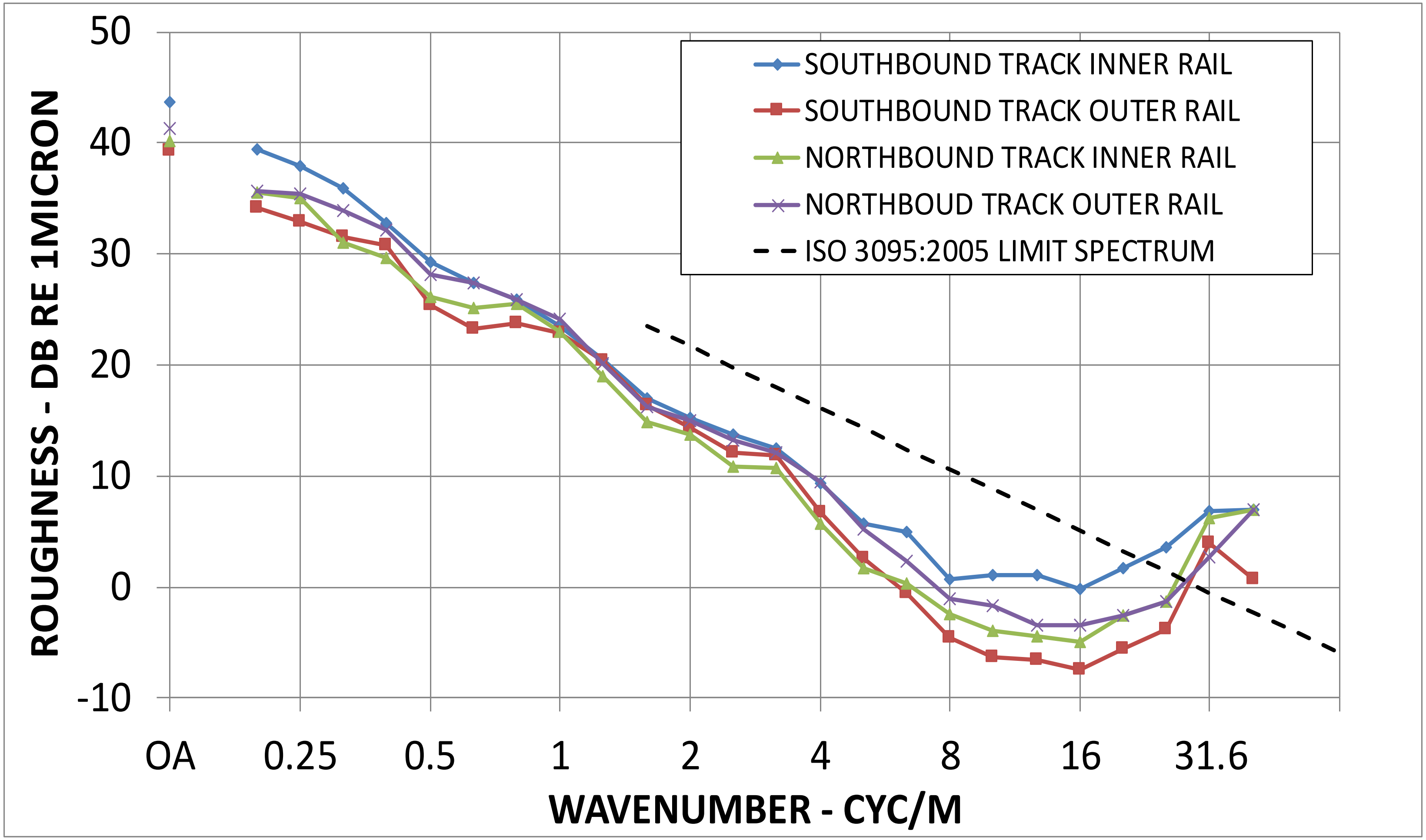
Lab Test - Vertical Accel



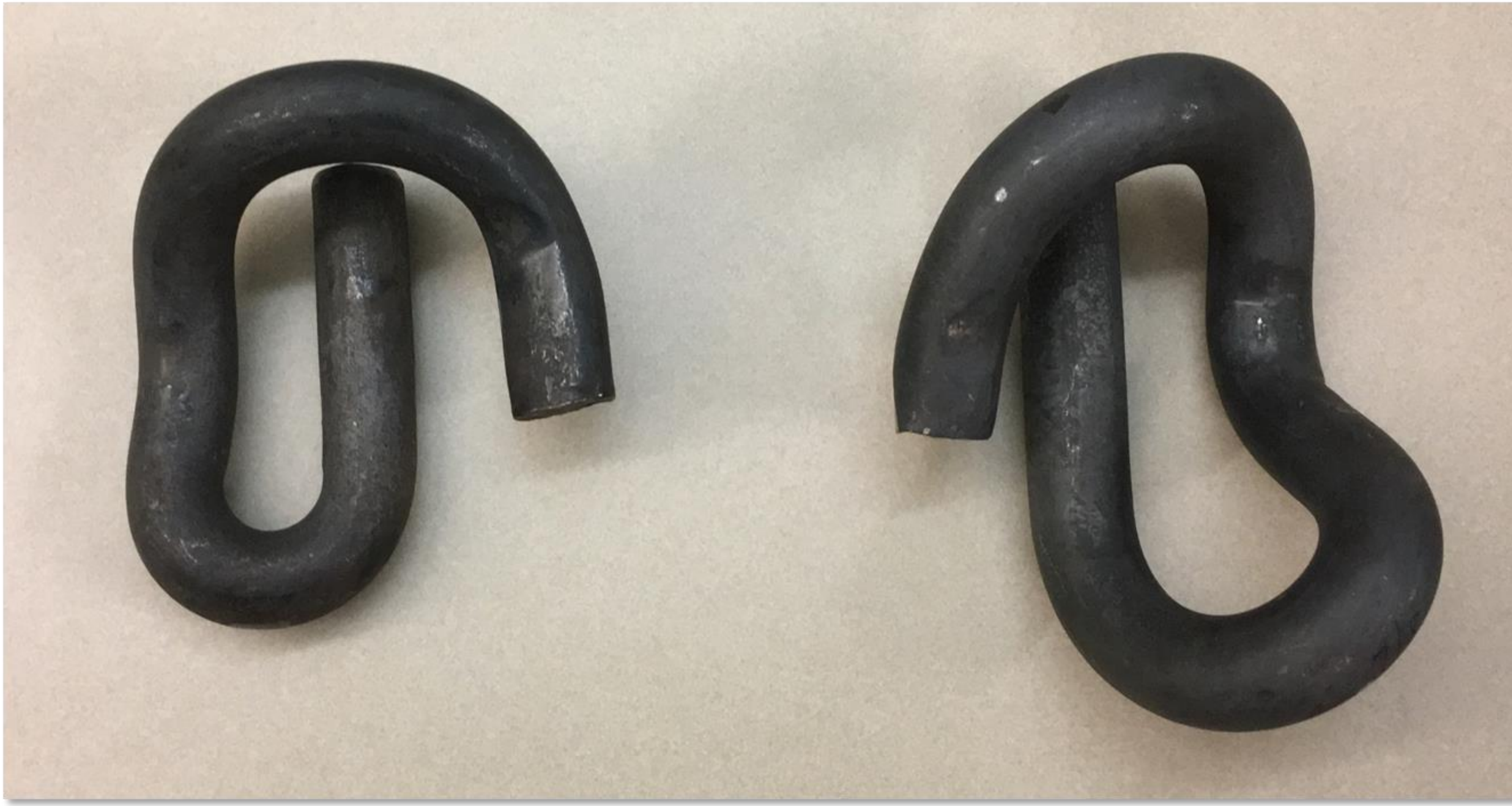
Laboratory Test – E-Clip



Rail Roughness Prior To Startup



Rail Clips



Conclusions

- Center truck produces largest rail rotation and lateral displacement
- No evidence of clip toe load being overcome
- No clear evidence of fatigue due to relative deflection of rail and fastener
- Acceleration spectrum contains strong peaks above 800Hz
- Laboratory tests indicate system resonance at about 800 to 900Hz
- Amplification of rail vibration acceleration at nominally 800 to 900Hz

Outline of ATS Presentation

- Background
- Measurements that were performed
- Analysis
- Conclusions
- Lessons Learned
- Moving Forward

Background...

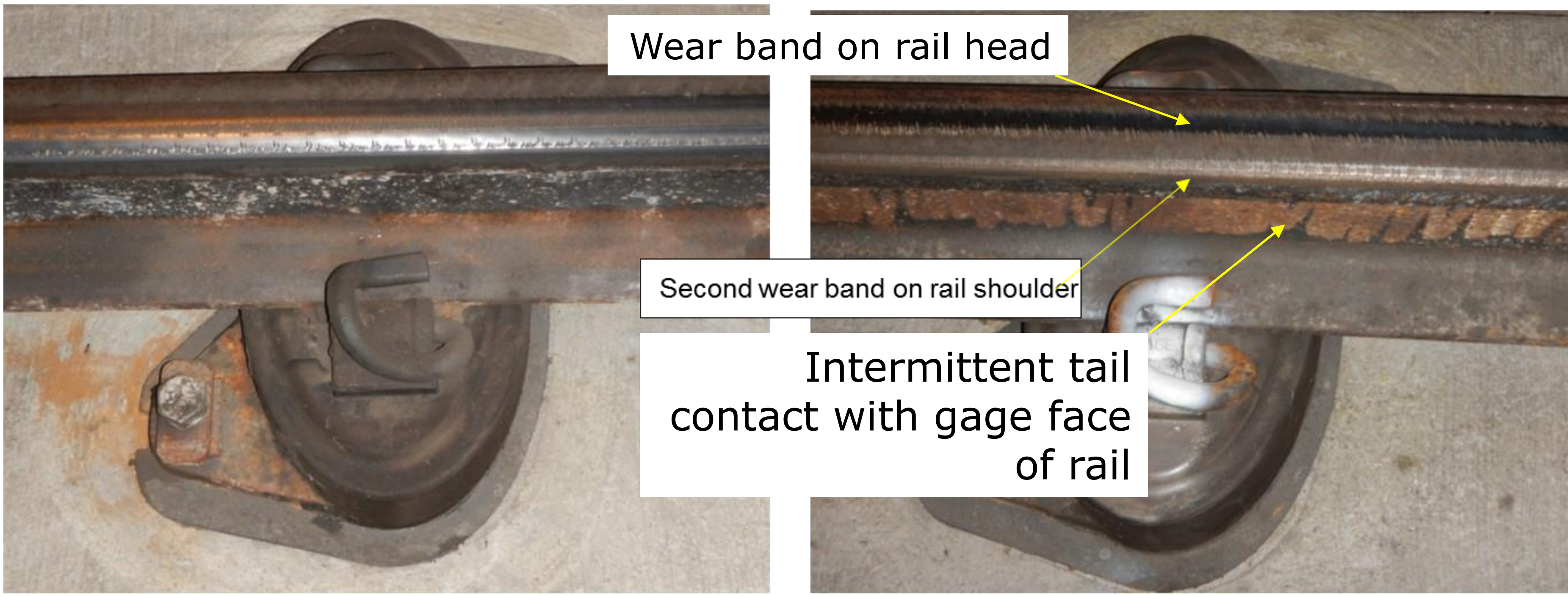
See Thom's previous presentation…

Program included:

- Two sites
  - UWS to CHS (subway)
  - SEA to ALS (aerial)
- Visual inspection of the rails
- Rail roughness/corrugation measurements using a Corrugation Analysis Trolley
- Noise measurements on the safety walks
- Onboard noise measurements using the CorrTracker system

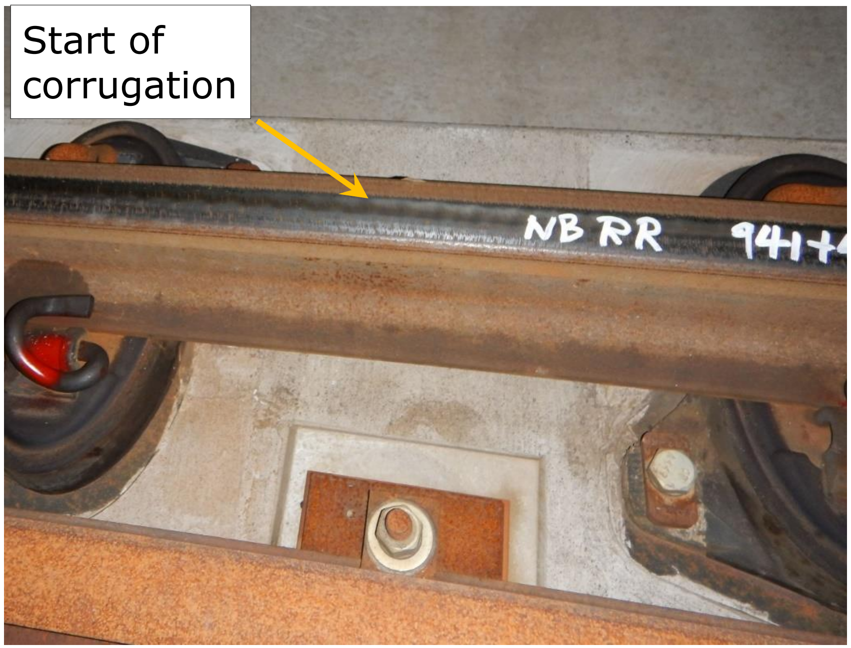
Visual Inspection

- UW Station to Capital Hill Station

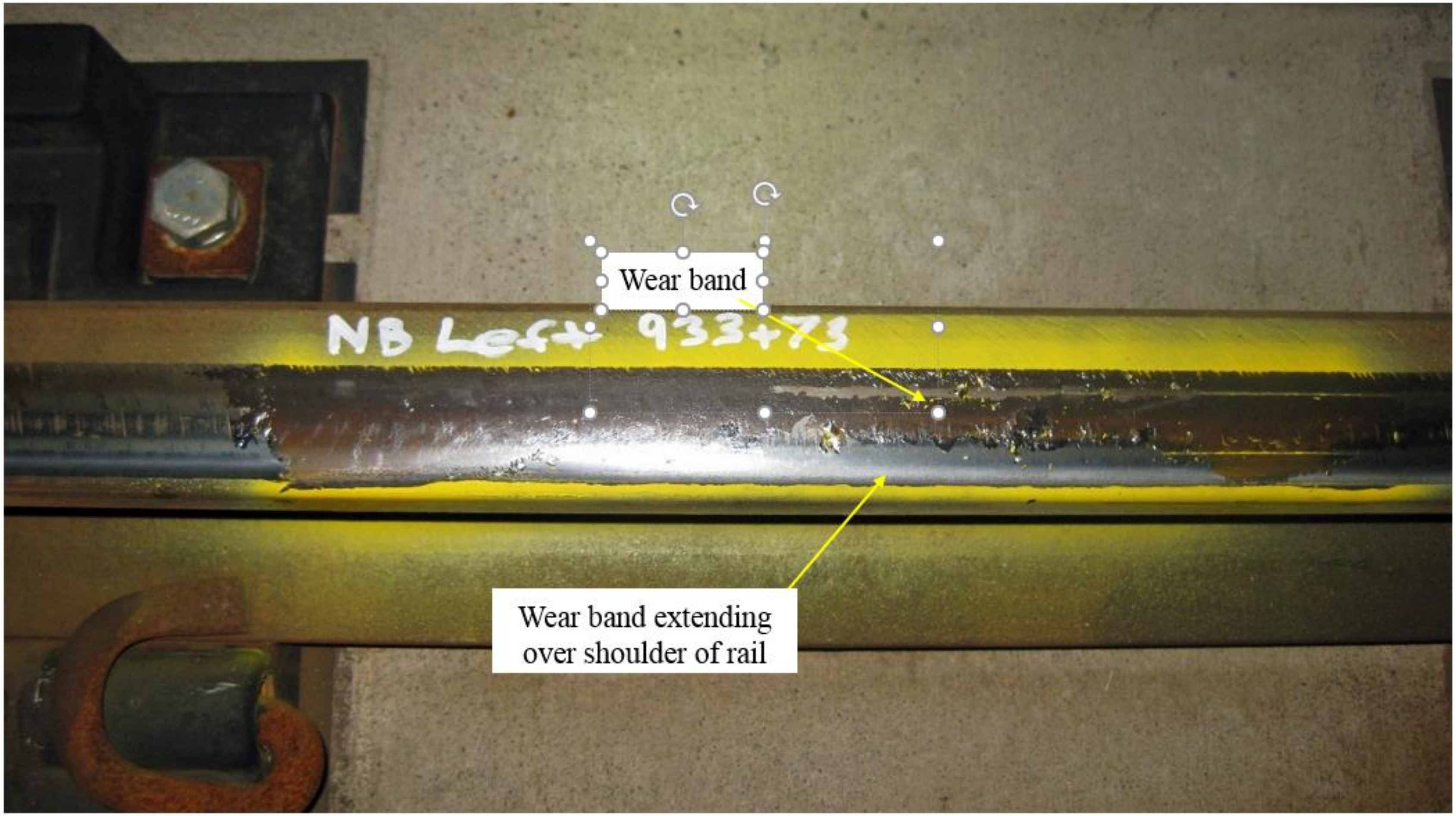


Visual Inspection

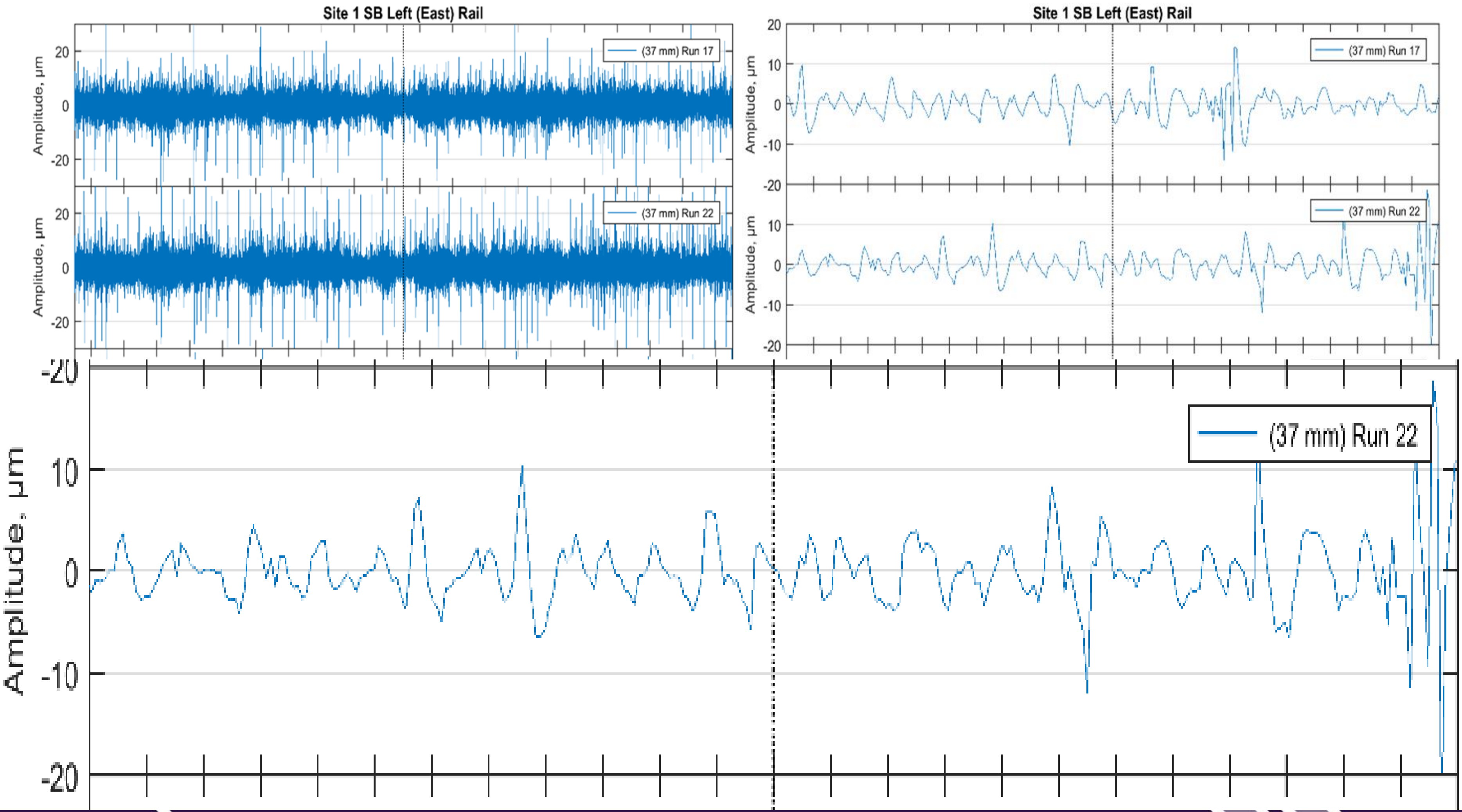
- SeaTac Station to Angle Lake Station



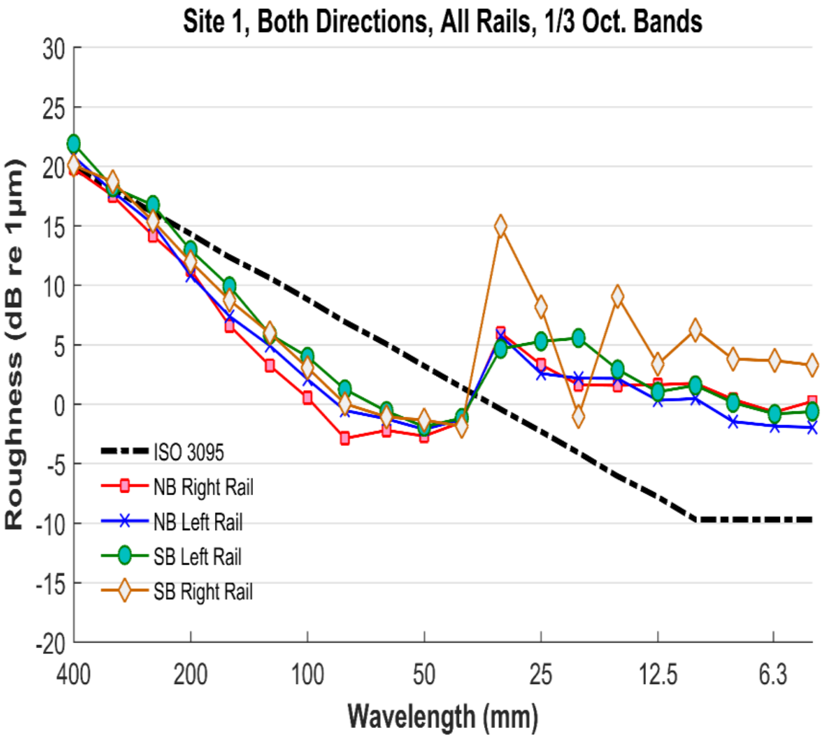
Painted rail after one day in service

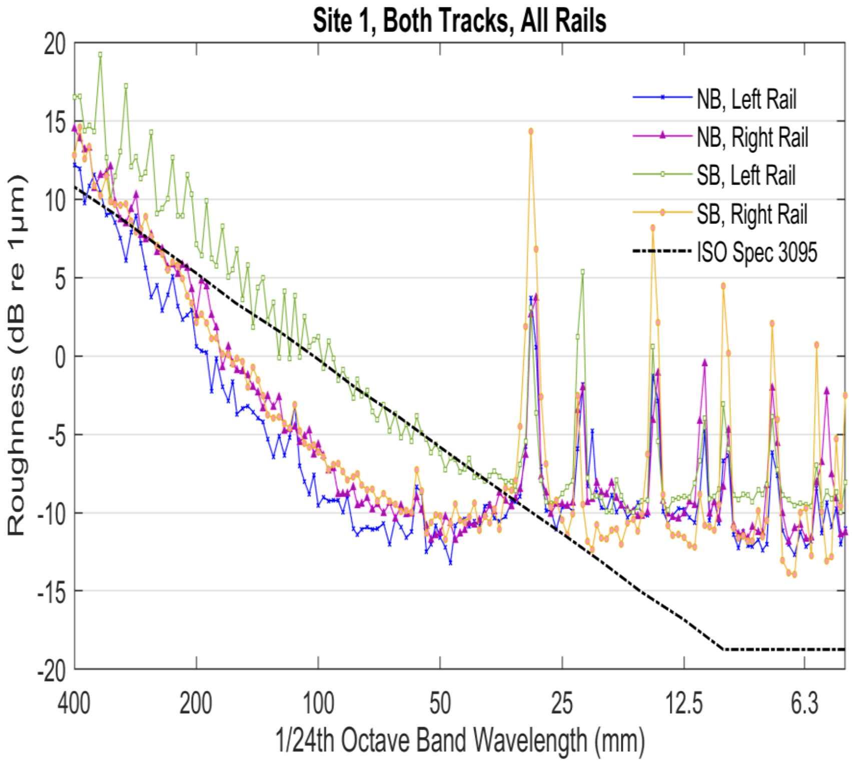


Raw Rail Roughness, UWS-CHS, 4 runs



Rail Rough Spectrums

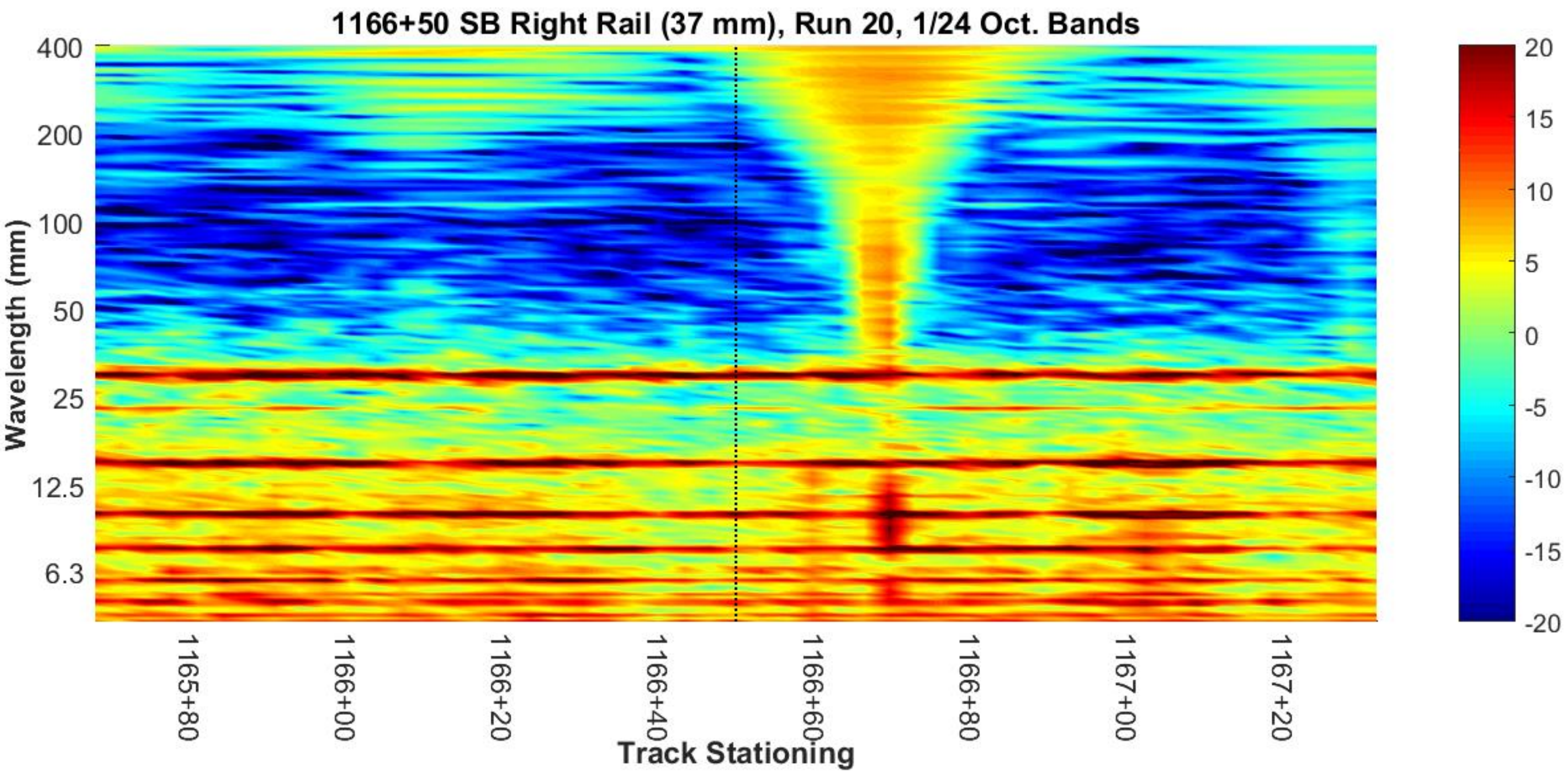




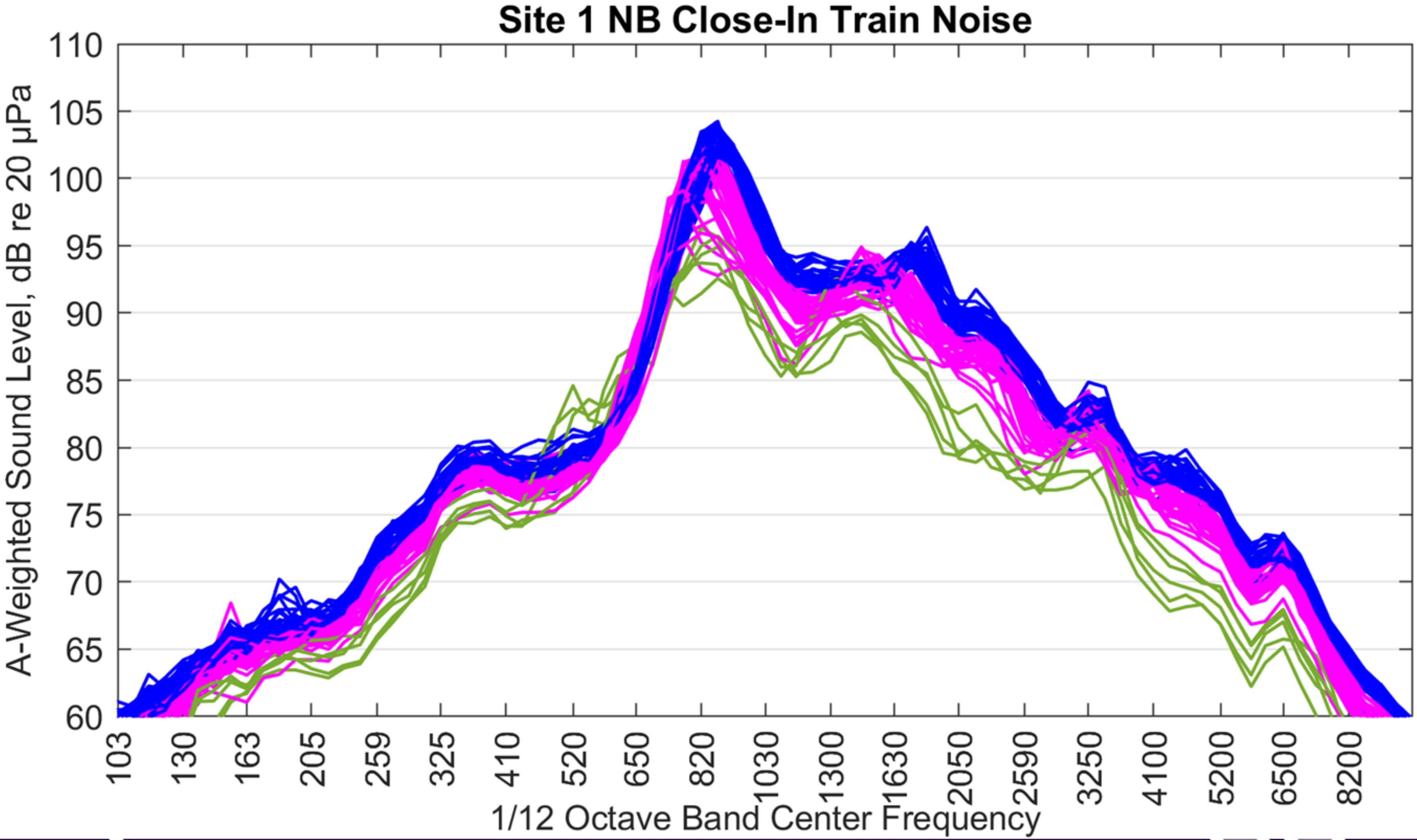
Roughness Wavelengths, Site 1

Wavelength, mm	Wavelength, in.	Frequency, Hz @ 55 mph	
28.99	**1.14**	848	
14.93	**0.59**	1647	
10.0	**0.39**	2459	
7.81	**0.31**	3148	
6.06	**0.24**	4057	
5.26	**0.21**	4674	
4.94	**0.19**	4977	

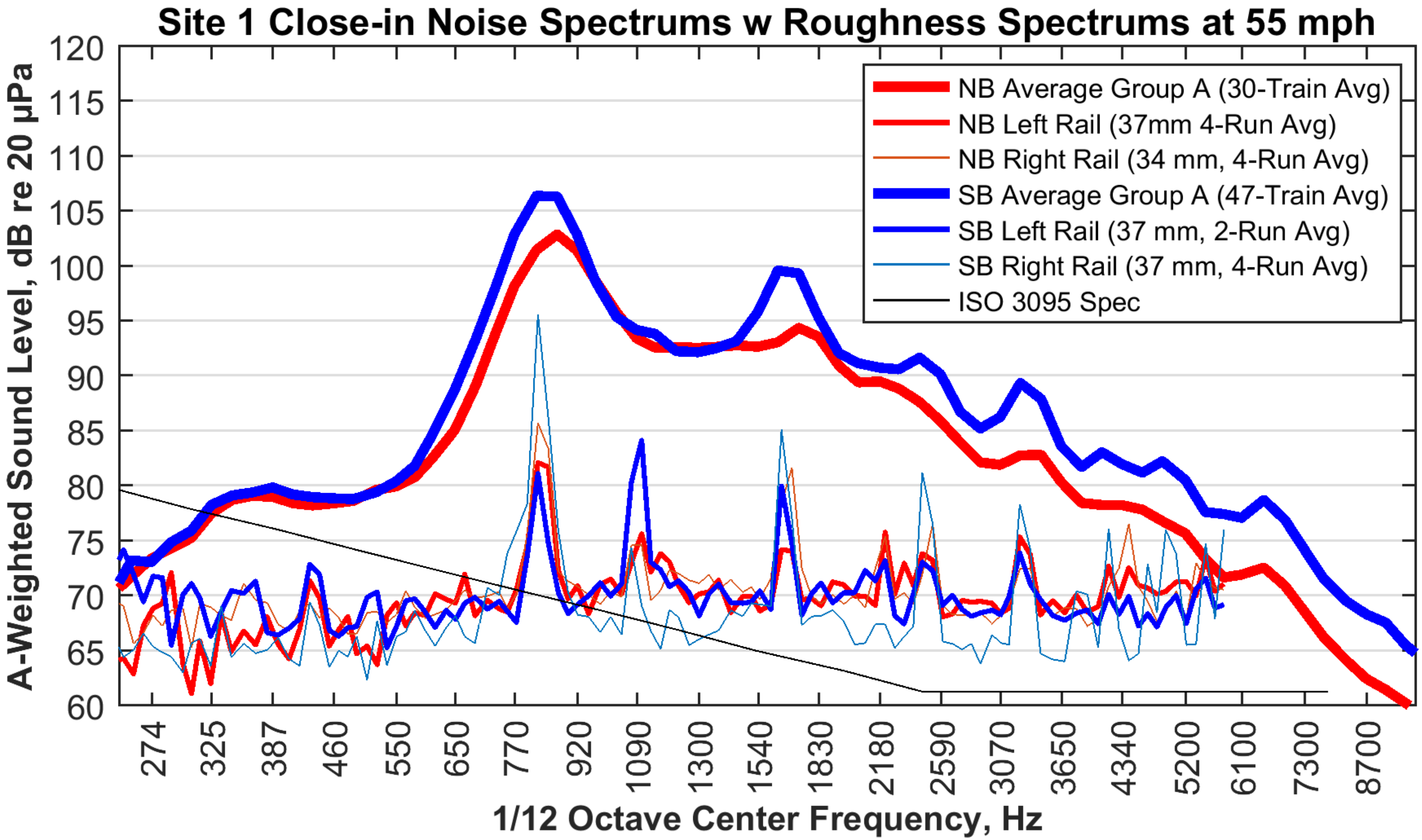
Roughness Spectrogram



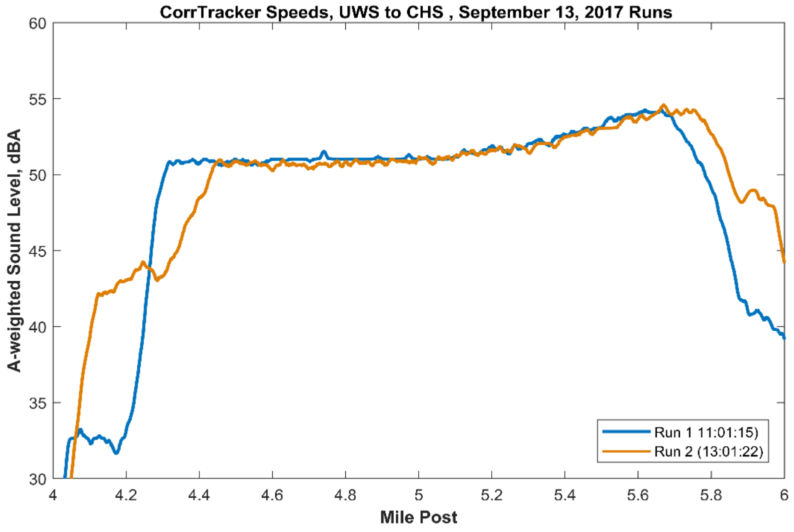
Safety Walk Noise, Tunnel

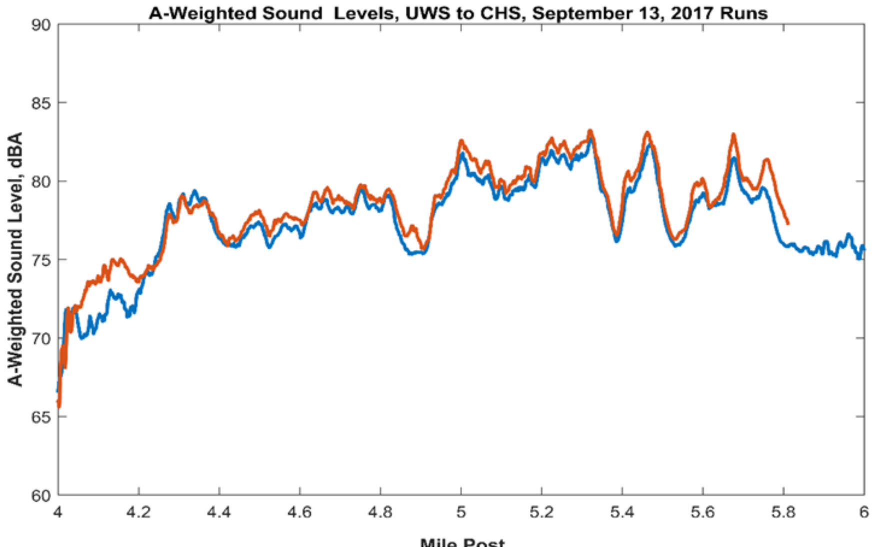


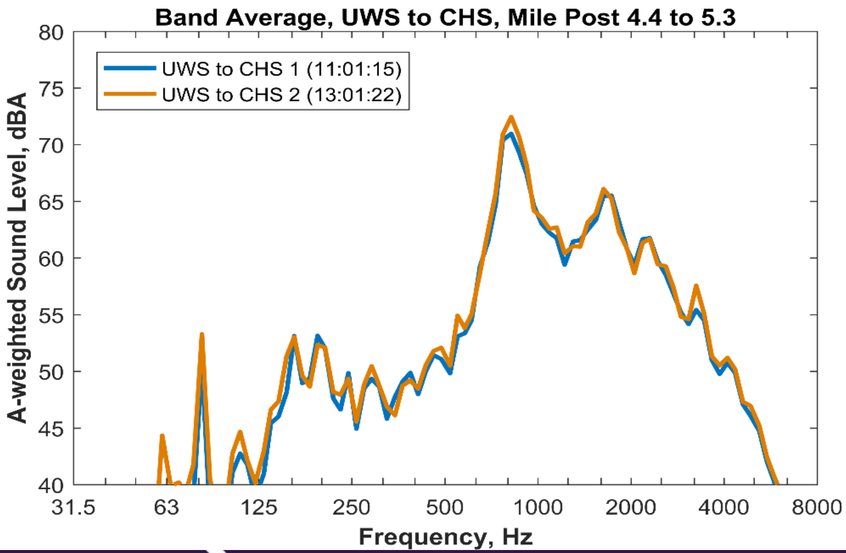
Safety Walk Noise and Roughness

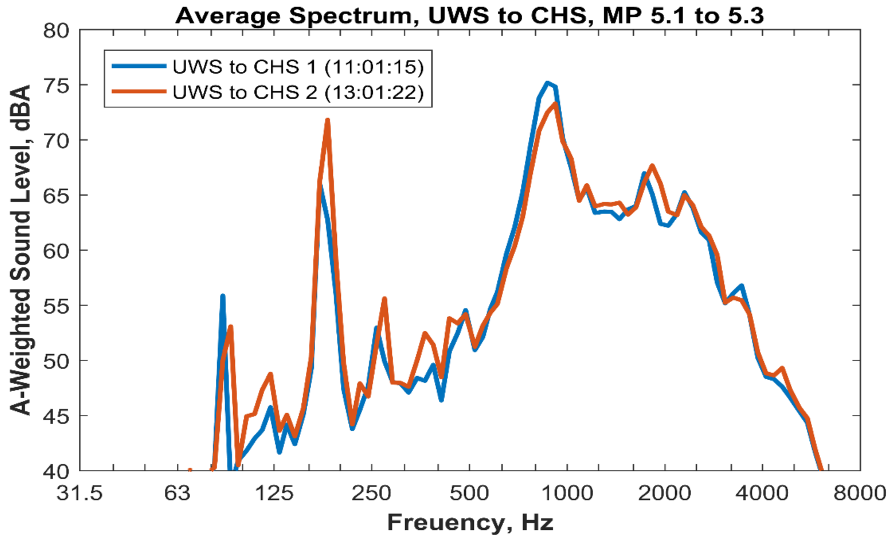


Onboard Noise, UWS to CHS

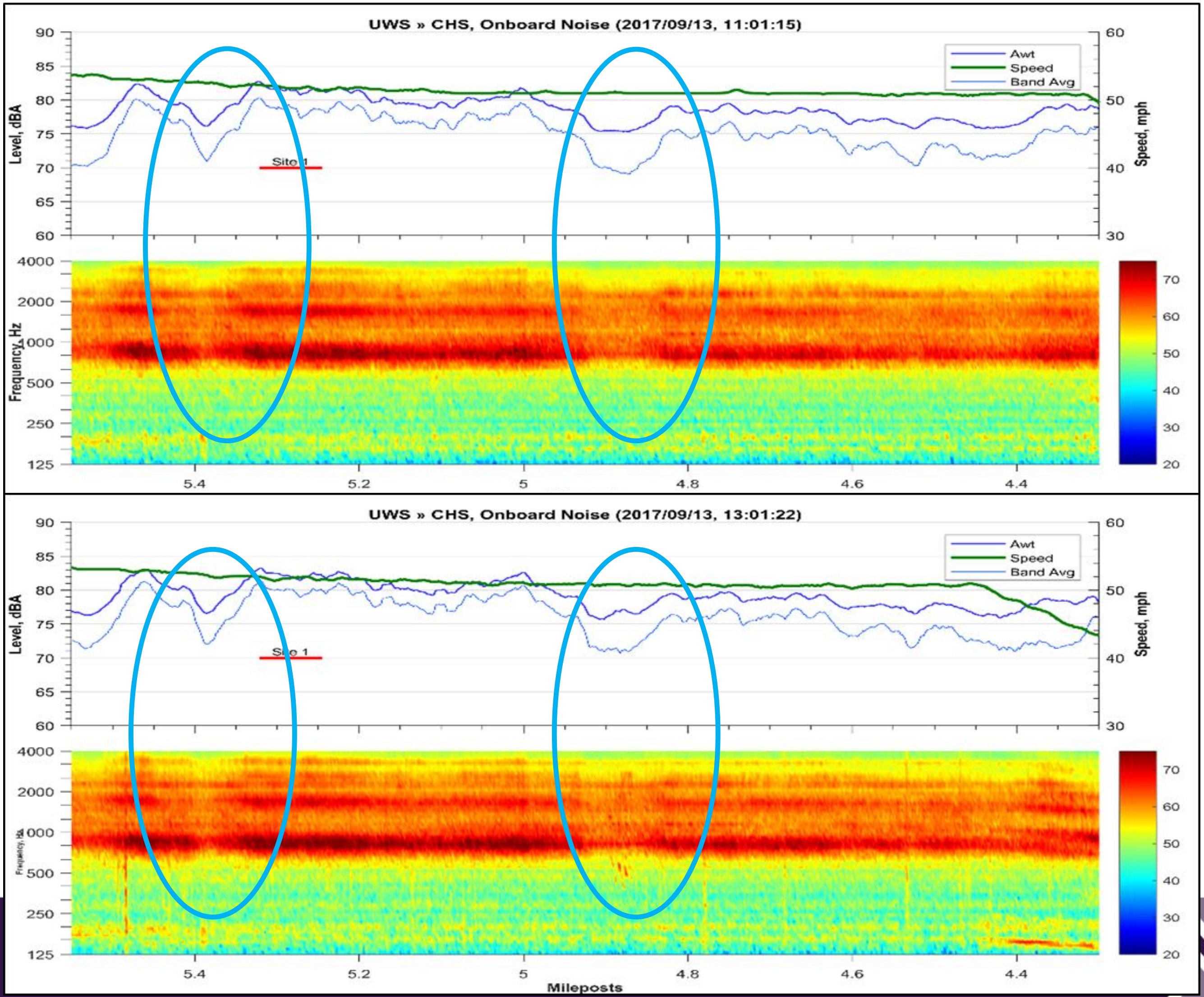








Onboard Noise, UWS to CHS



Conclusions

- Rail grinding left ~1.1″ wavelength.
- At 55 mph, 1.1″ wavelength causes vibration at 848 Hz.
- There are short segments where this wavelength disappears.
- Resonance of rail clips is 800 to 900 Hz.
- Rail clip failures appear to be greater where 800 to 900 Hz peak is stronger.
- Reducing or increasing the grinder speed would change the wavelength and could help resolve problem.

General Observations

- Future measurements should include track time for follow up inspections.
- Onboard measurements can be a valuable tool for identifying problem areas.
- Rail grinding specifications should be updated to address this issue.
- Sound Transit is investigating various approaches.

Acknowledgement

- Shankar Rajaram / Sound Transit
- Xiangdong Han / Sound Transit
- Jason Bailey/ Sound Transit
- Anthony Bohara / HDR

Thank You!

Questions?