

# Wheel-Rail Interface Conference

## May 6, 2013

### Using on-board & wayside noise measurements to monitor track condition and prioritize rail grinding

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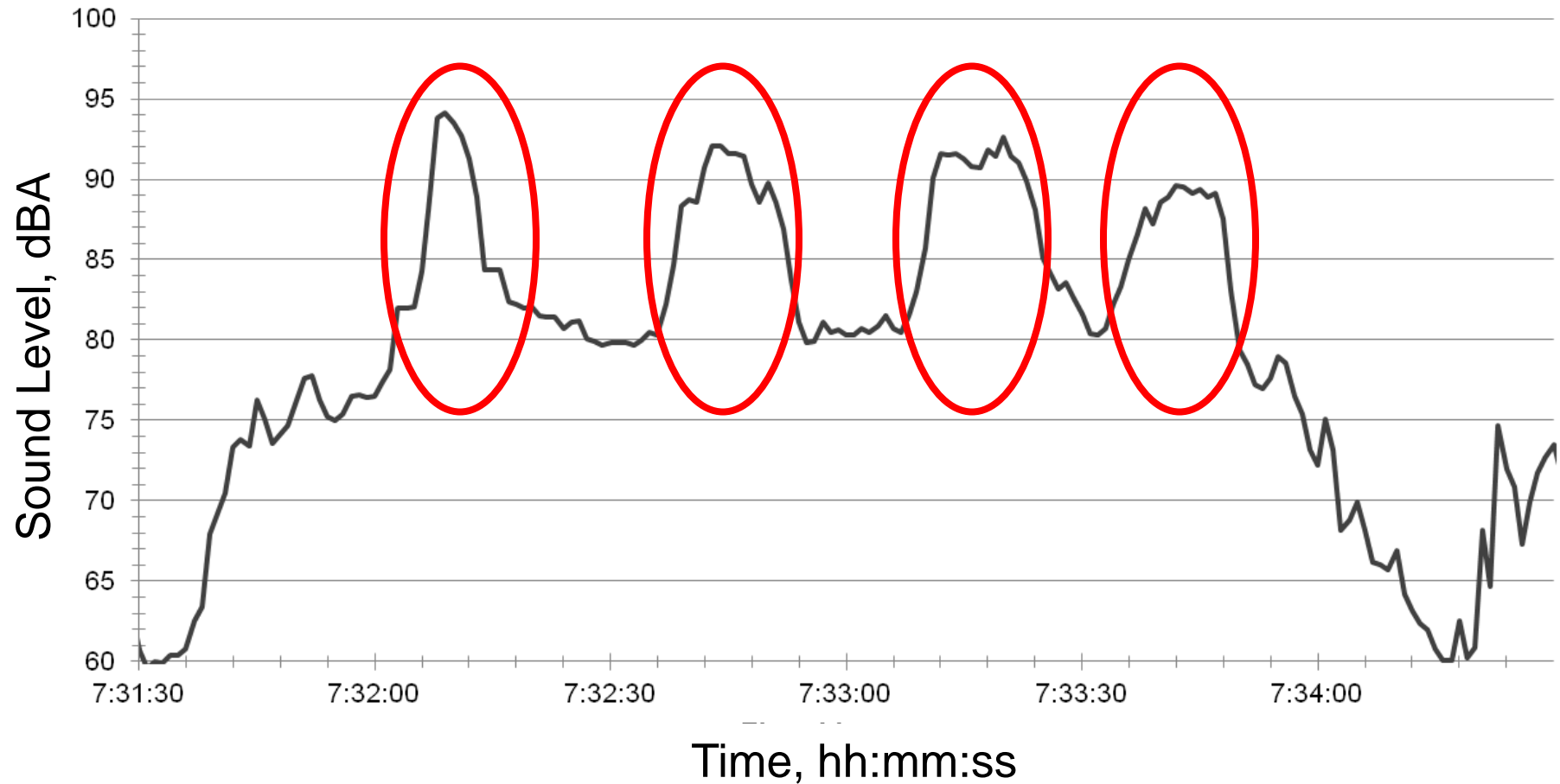
# Outline

- Background
  - Terms
  - How to read the figures
- ATS Corrugation projects
- Case Study:
  - Long term corrugation and noise monitoring on BART
- Conclusions and Future Extensions



# On-Board Noise Measurement, 2003

## In-Car Noise, San Bruno to South San Francisco



# Why is rolling noise on one system louder than another?

- Corrugation
- General condition of wheels and rails
- Vehicle characteristics (e.g., wheel skirts)
- Track structure (e.g., rail vibration decay rate)
- Properties of wheels (e.g., solid vs. resilient)
- Wheel and rail profiles
- Lubrication



# Background

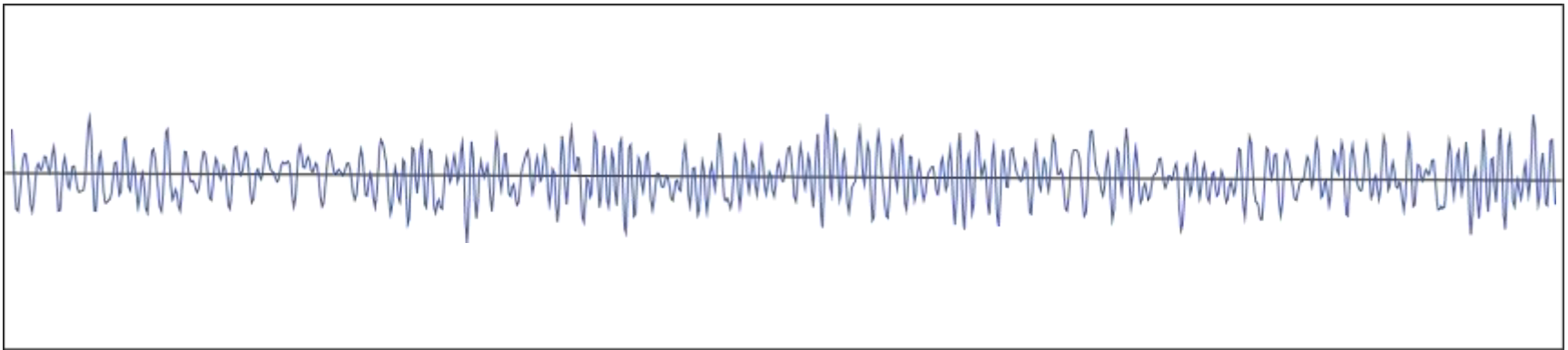
- ATS has worked to detect corrugation at several systems
- Many approaches to solving problem
- What works in one location may not work elsewhere
- Factors thought to contribute to corrugation include
  - Slip-stick between wheels and rail
  - Wheel and rail profiles
  - Tightness/looseness of gauge
  - Curve vs. tangent track
  - Tightness of curves
  - Metallurgy (micro and macro)
  - Other...



# **“Random”**

## ***Roughness from wear***

### ***Random Roughness***



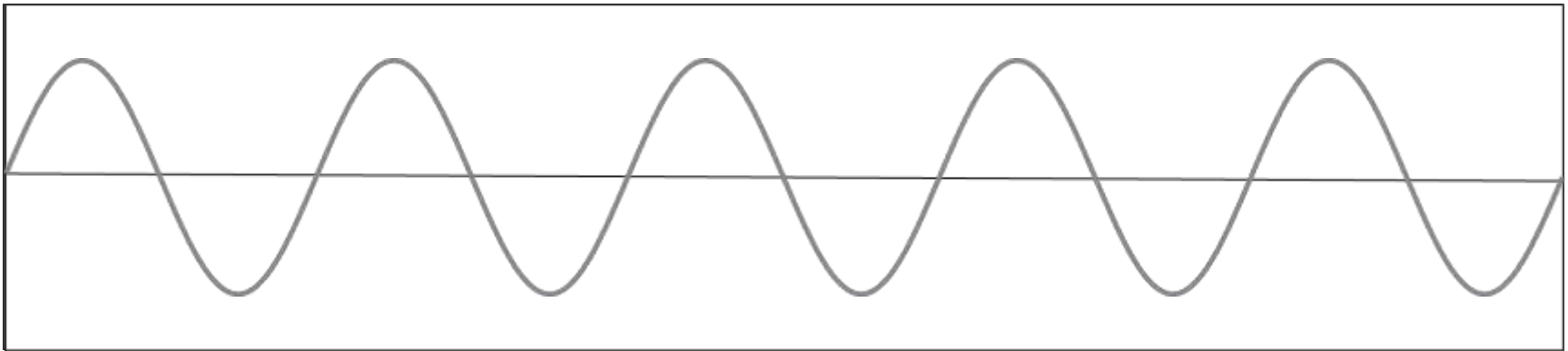
$$\begin{aligned} \text{frequency} &= \text{speed} / \text{wavelength} \\ &= 17.9 \times \text{speed}(\text{mph}) / \text{wavelength}(\text{inches}) \\ &= 447 \times \text{speed}(\text{mph}) / \text{wavelength}(\text{mm}) \end{aligned}$$



# “Corrugation”

***Sinusoidal pattern induced in the rail by normal vehicle operations***

***Corrugation***



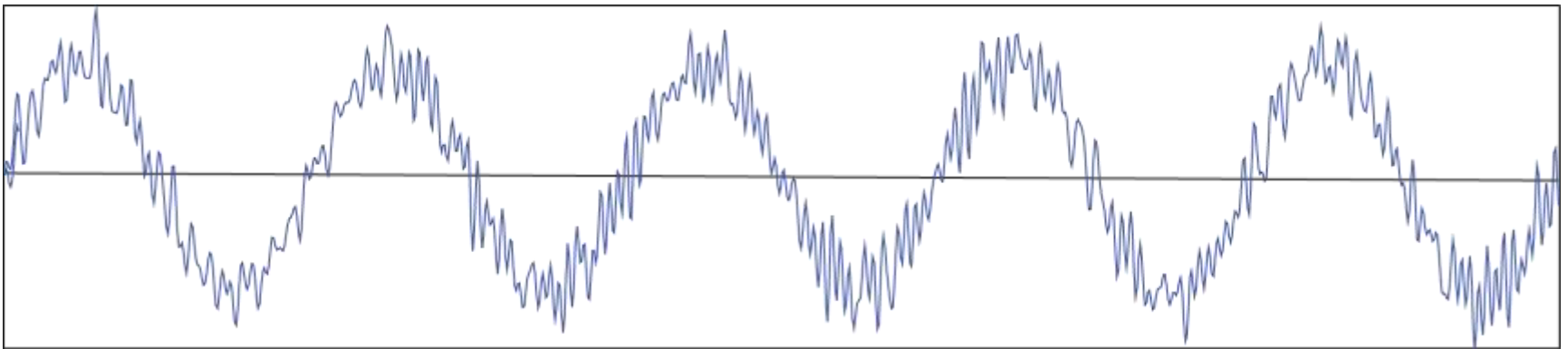
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# “Roughness”

***Any longitudinal irregularity in rail surface***

***Combined Corrugation and Random***



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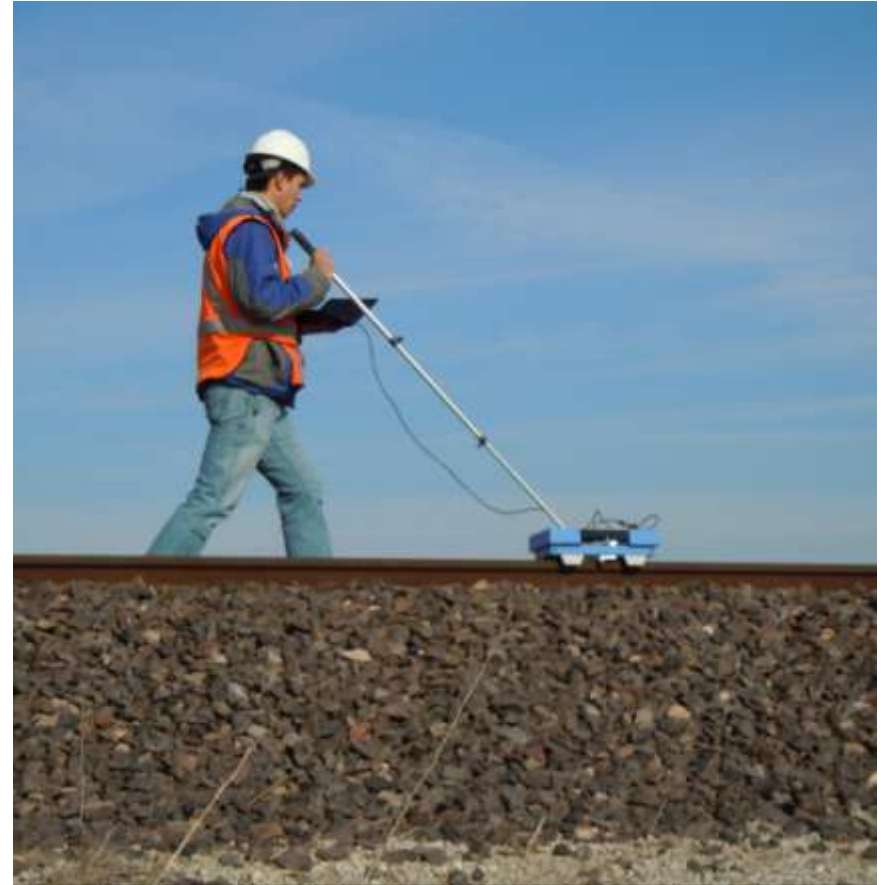
# Recent ATS Experience

- **St. Louis Metrolink:** Identify problem spots to prioritize grinding
- **Seattle Sound Transit:** Wheel rail study to diagnose higher than expected noise levels
- **Los Angeles Metro:** Noise complaint troubleshooting
- **Bay Area Rapid Transit:** Long term study: rail corrugation and dampers
- **San Diego Metropolitan Transit System:** Quality control for grinding
- **Minneapolis Metro Transit:** Full system measurement prior to identify locations for grinding
- **New York AirTrain:** Site specific measurements prior to grinding
- **Sacramento Regional Transit:** Site specific measurements before/after grinding, determine noise reduction that could be achieved with improved grinding and wheel truing procedures

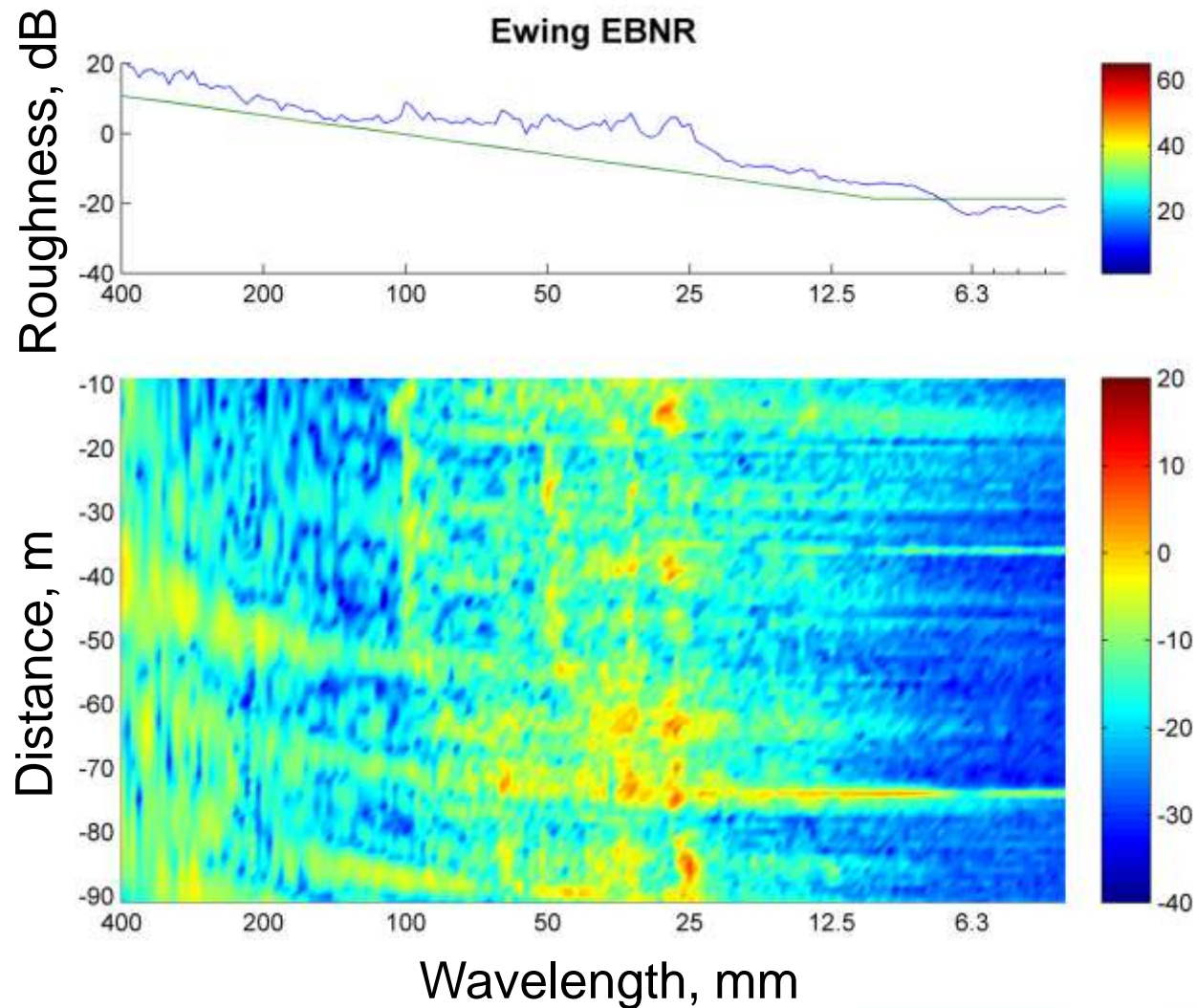


# Direct Roughness Measurement

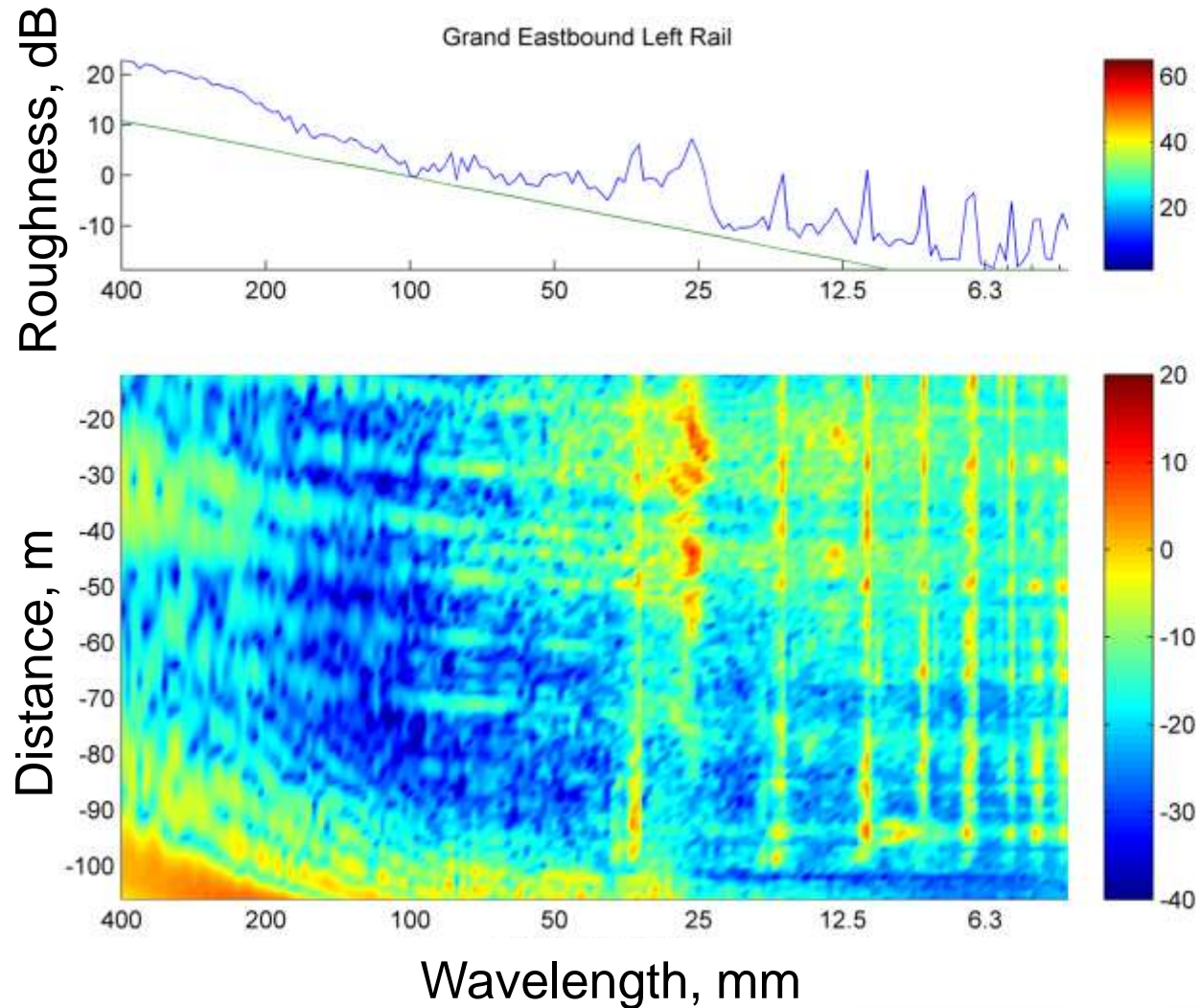
- Small cart measures the rail head
- Can measure wavelengths as short as 2 mm
- Typically measure distances up to 200m



# St. Louis Before Grinding



# St. Louis After Grinding



# Wayside Noise

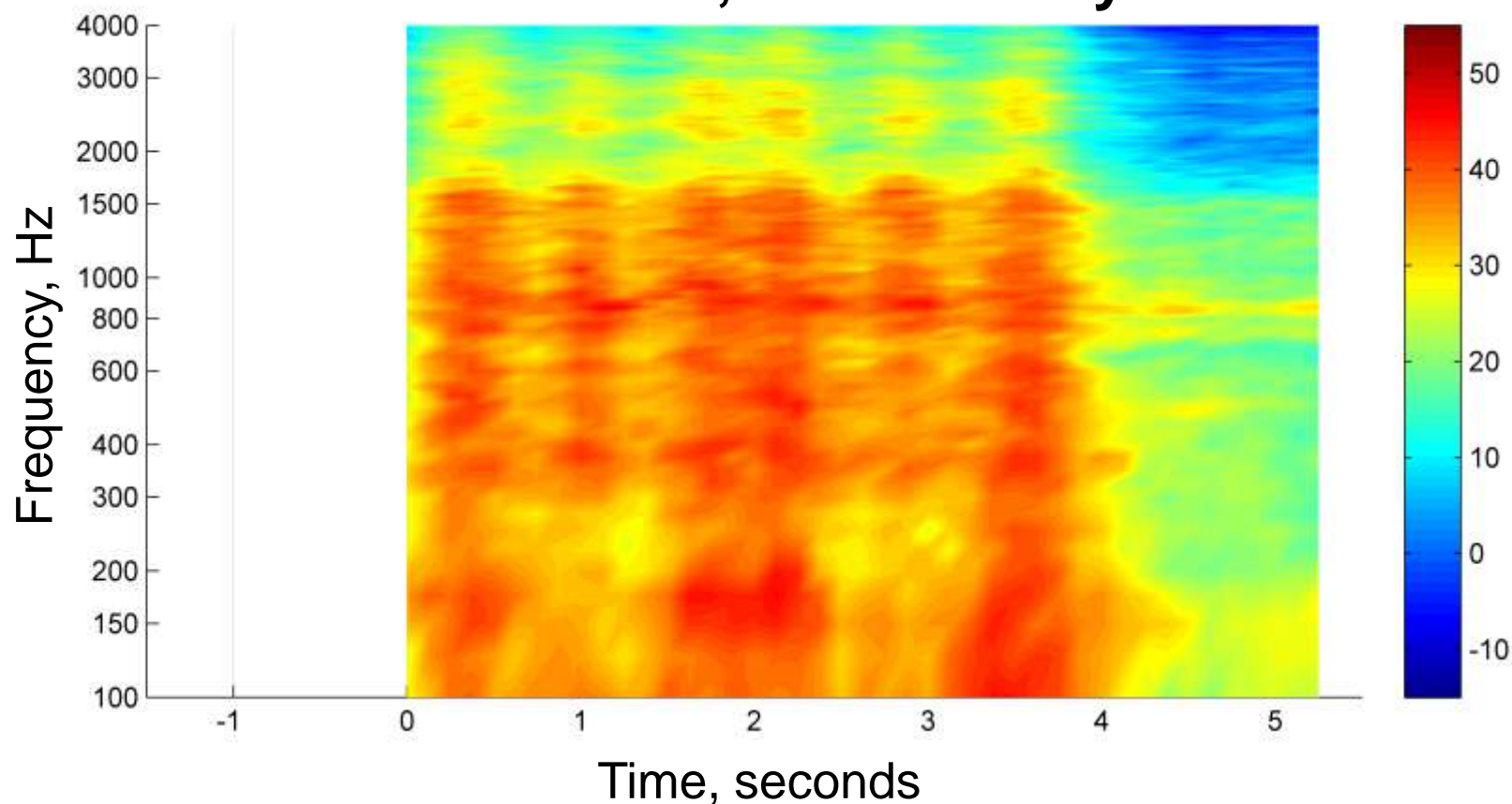


- Microphones placed at the track wayside
- Distances of 1m, 7.5m, 15m
- Measure noise as trains pass measurement position



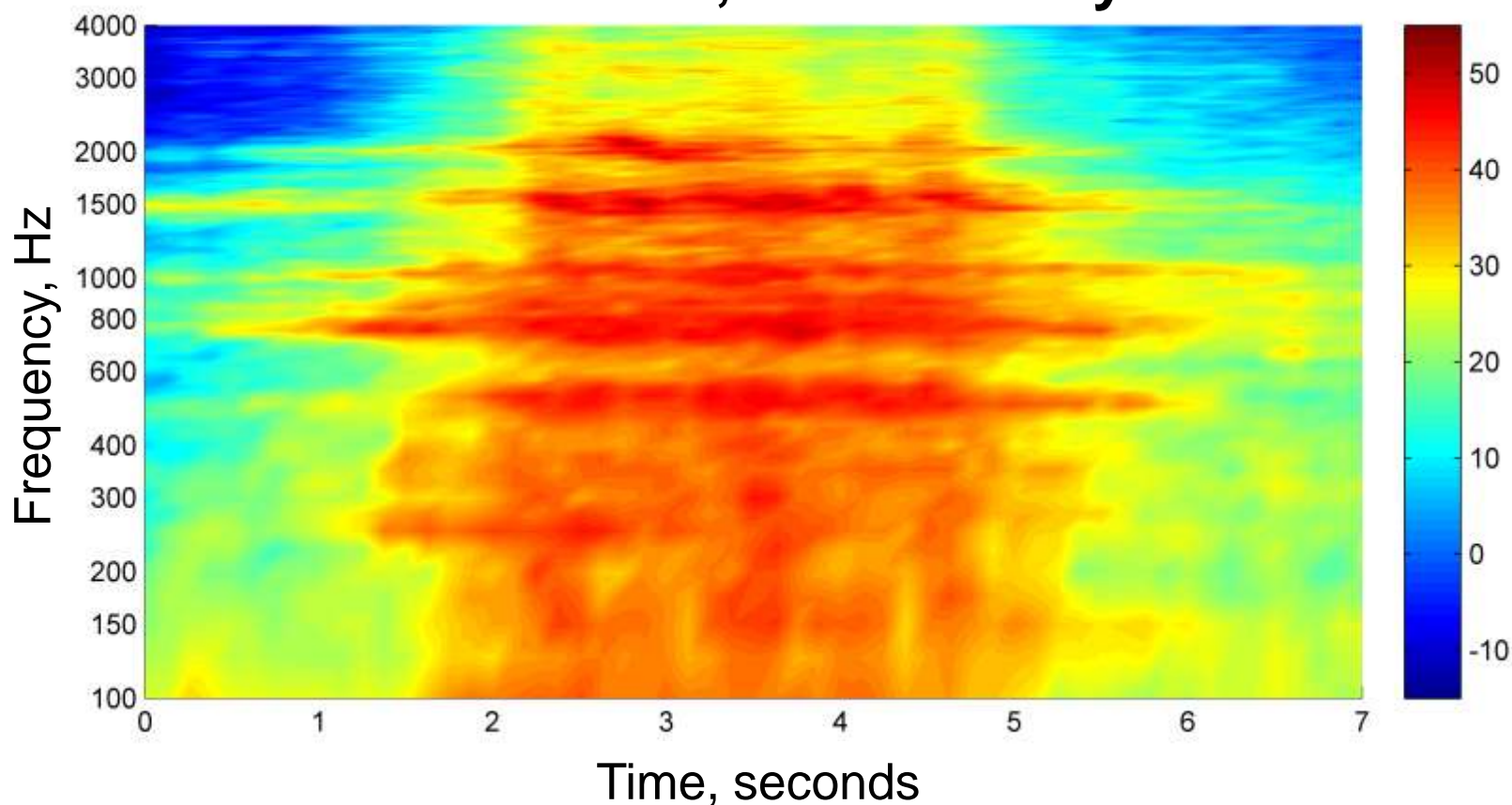
# Seattle Wayside Noise

## Train Noise, 1 meter away



# Seattle Wayside Noise

## Train Noise, 1 meter away



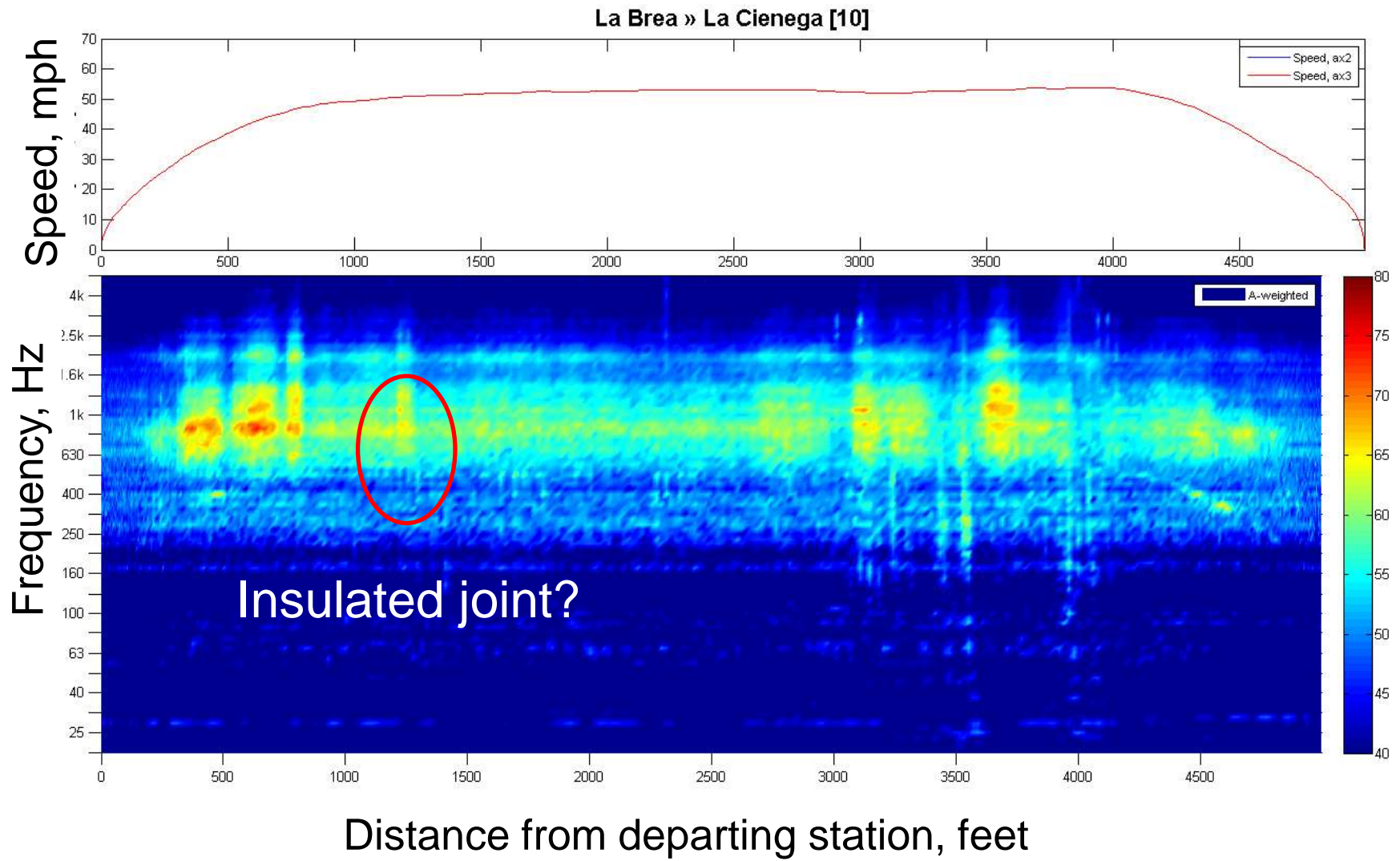
# On-board Noise Measurements



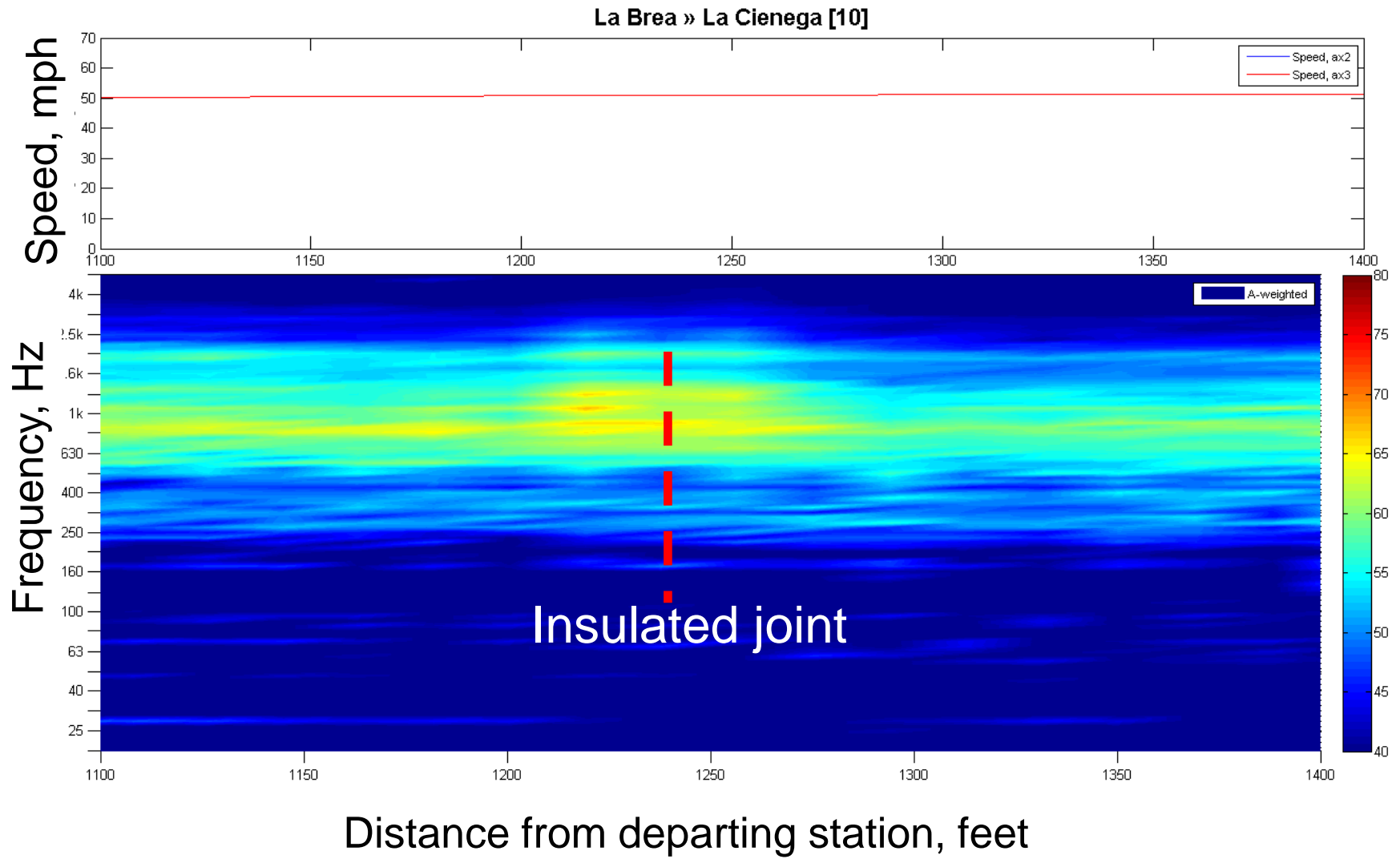
- Fast setup
- Mounts easily in cab
- Works in tunnels
- Full wave playback
- One-man crew
- Representative of rider experience
- Examine entire system quickly



# LA Expo On-board Noise



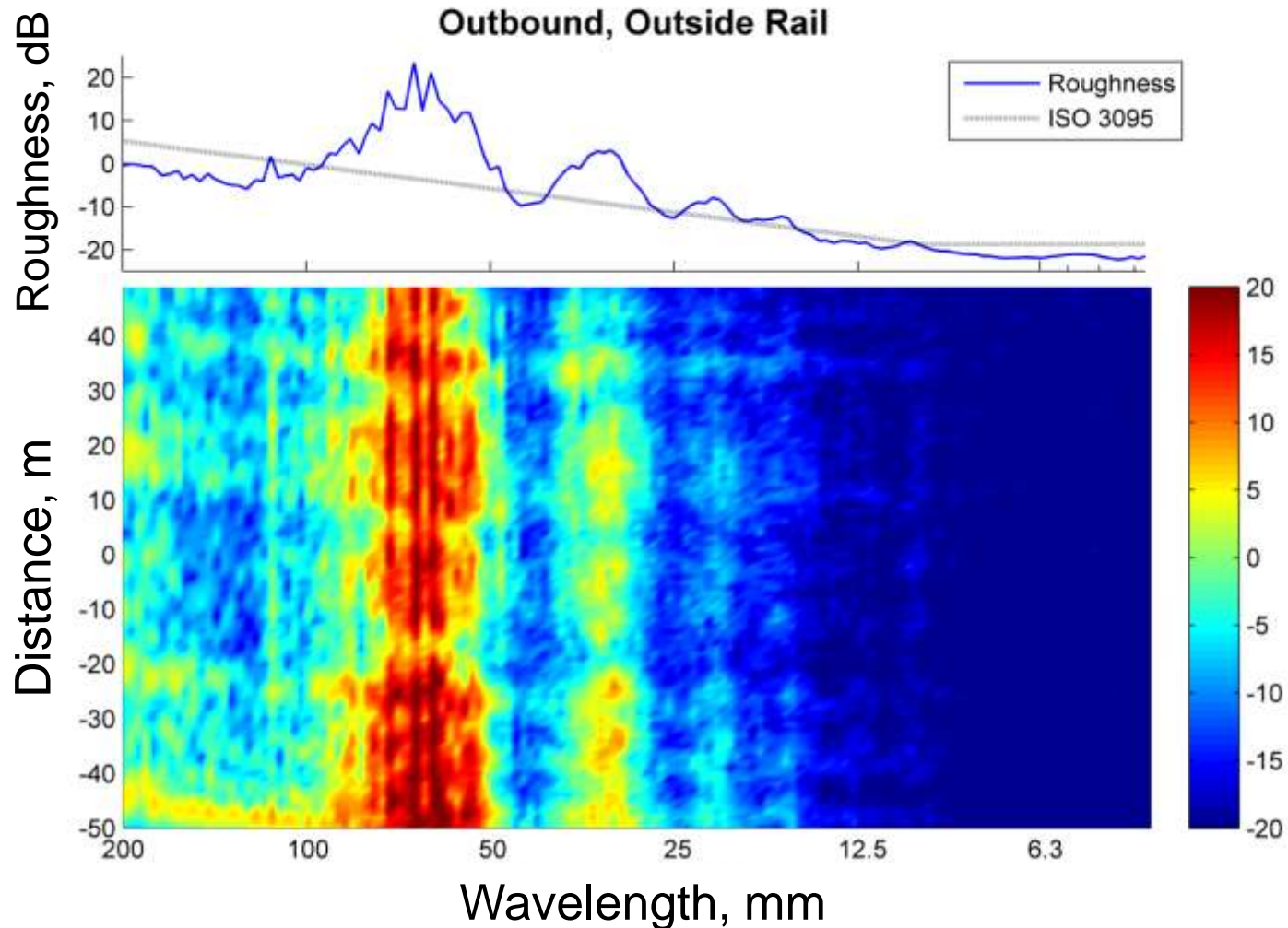
# LA Expo On-board Noise



# Rail Head Near Insulated Joint



# BART Aerial Structure



# BART Aerial Structure



# Monitoring System Wide Corrugation at BART

## Goal:

- Prioritize locations for rail grinding
- Optimize rail grinding efforts
- Search for parameters that correlate with corrugation (track type, curvature, fastener type, speed, gauge, wear, ...)
- Monitor corrugation growth

## Approach:

- “On-board” Noise measurements in trailing vehicle operator’s cab



# Addressing Corrugation at MP 7.1

## Goal:

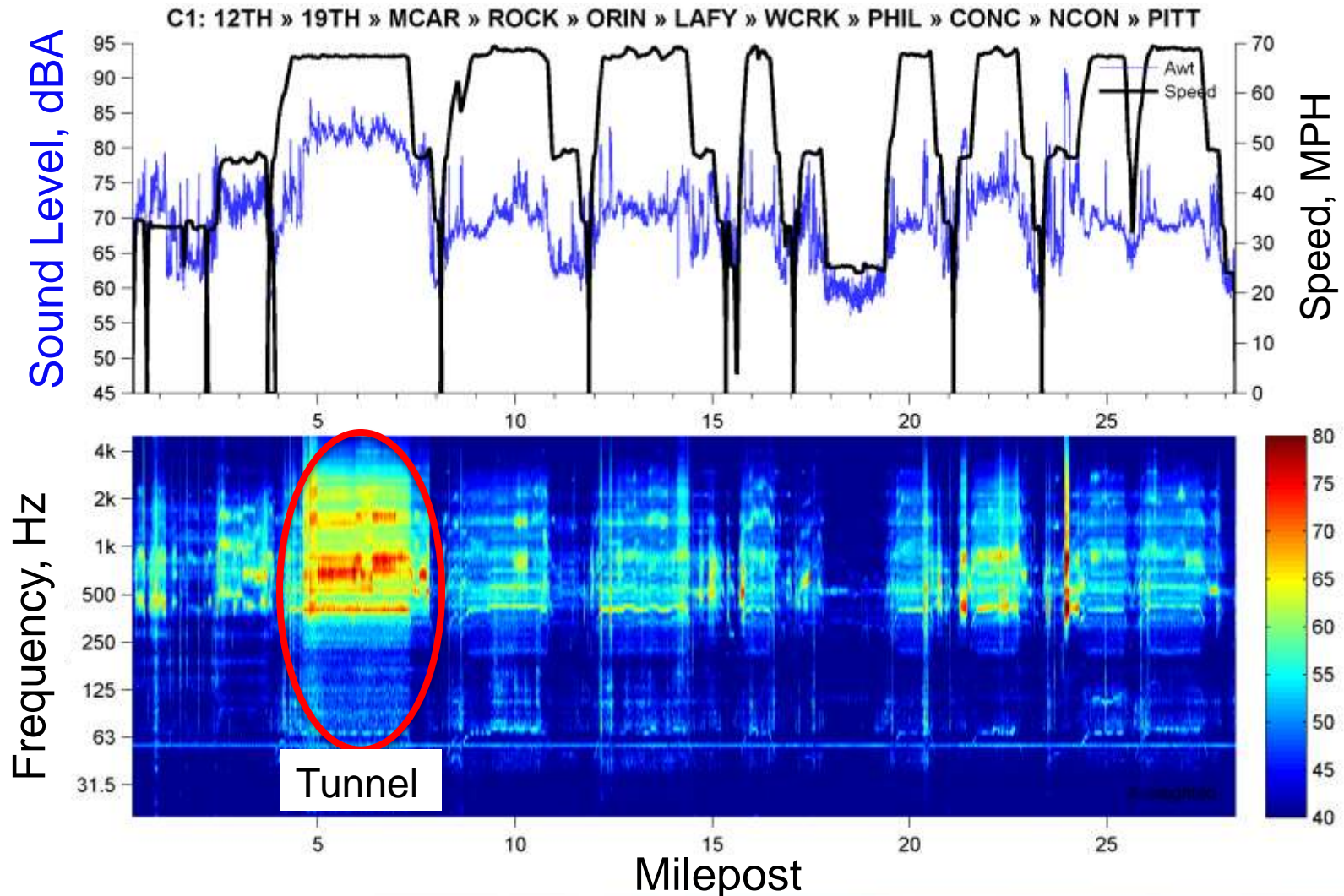
- Monitor noise levels over time
- Quantify effectiveness of rail grinding
- Quantify effectiveness of rail dampers
- Monitor growth of rail corrugation with and without rail dampers
- ***Find a solution to rail corrugation!!***

## Approach:

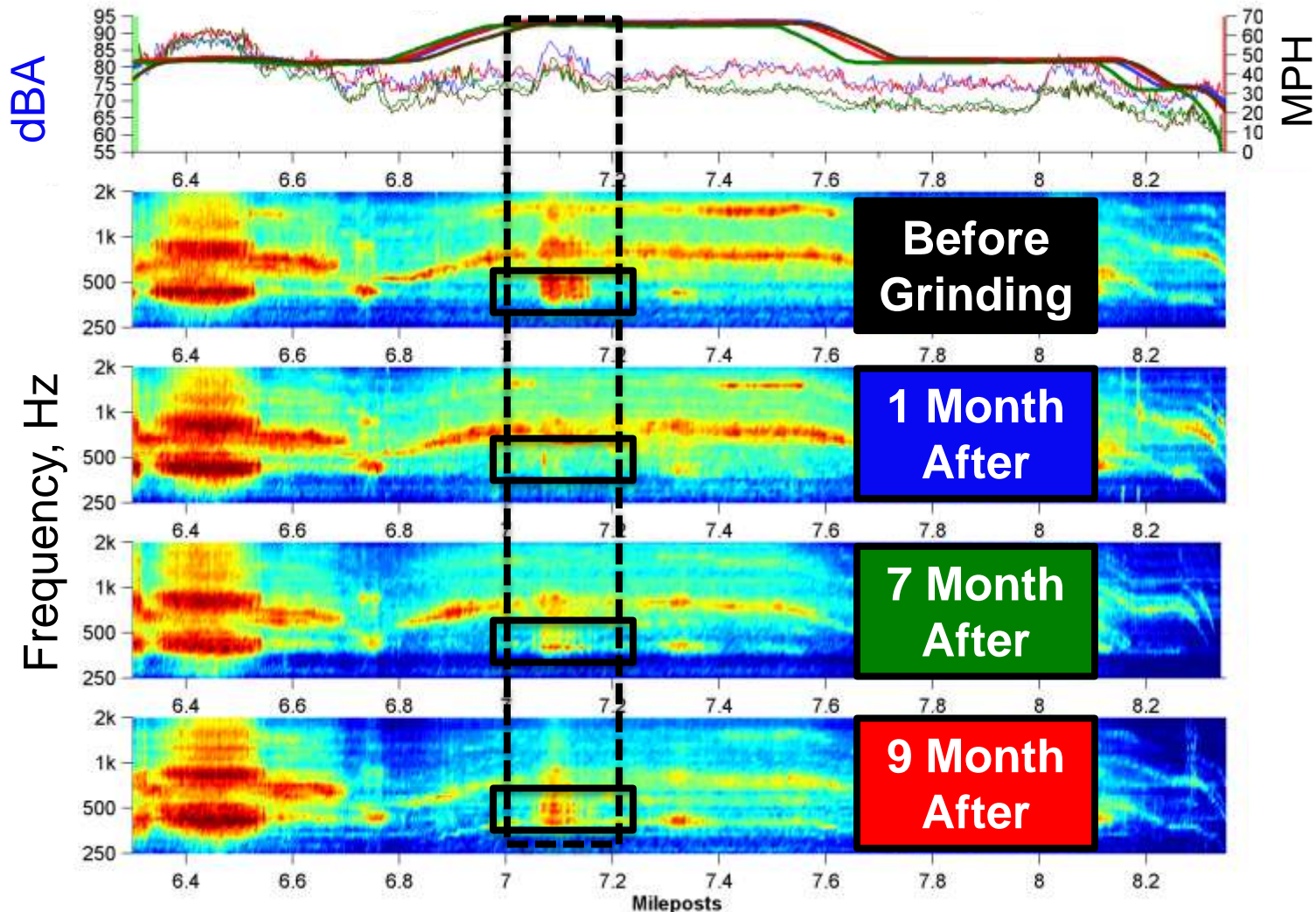
- On-board noise, wayside noise, and rail roughness
- Test rail dampers
- Examine rail grinding procedures (ARM)



# Visual Overview by Track

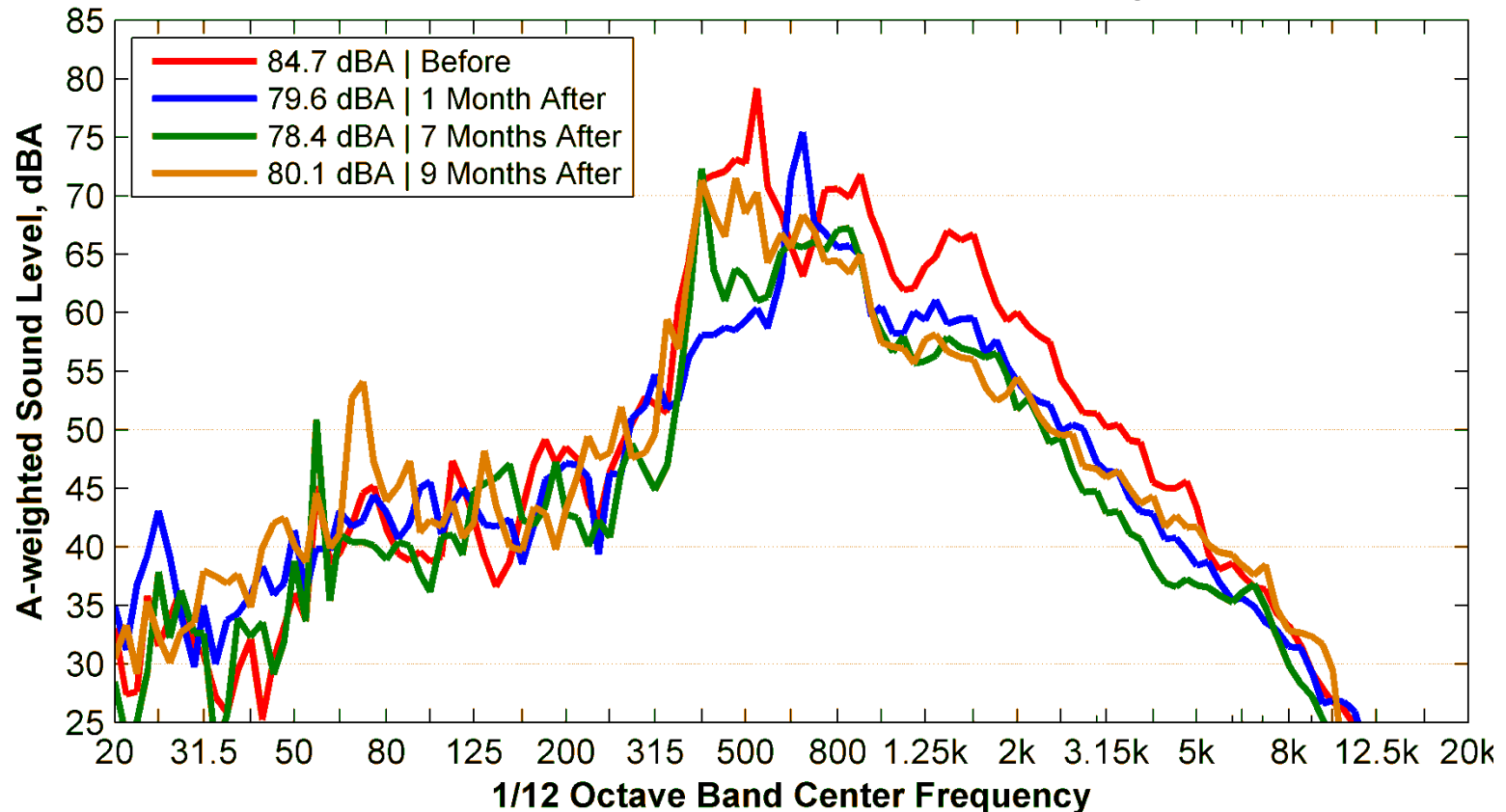


# Tracking Corrugation Growth Using Onboard Noise

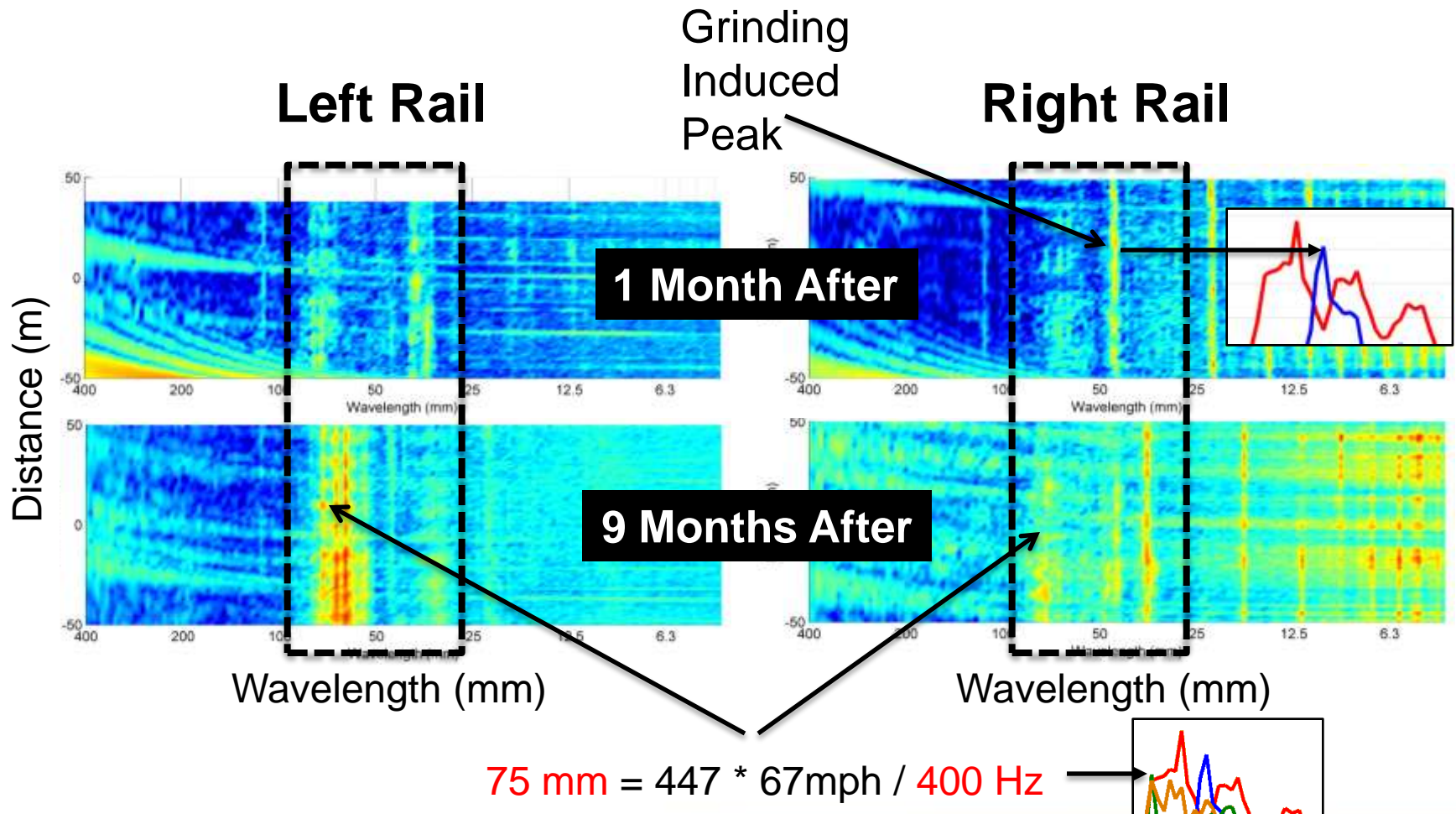


# Tracking Corrugation Growth Using On-Board Noise

Onboard Train Noise Spectrum at Grinding Location



# Tracking Corrugation Growth Using Rail Roughness Measurements

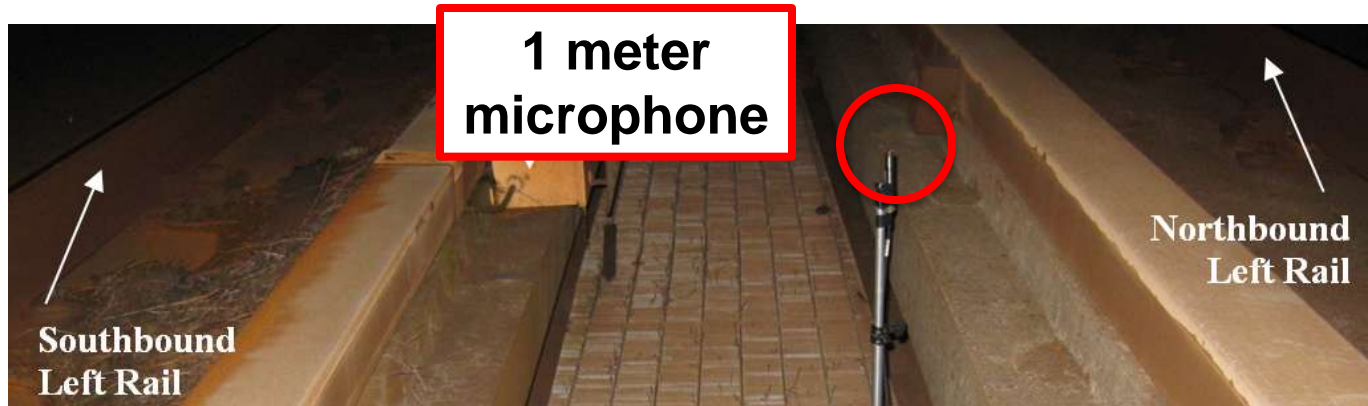


# Quantify Effectiveness of Rail Dampers

- Installed January 2013
- Rail ground March 2013
- Corrugation growth tests have not been performed

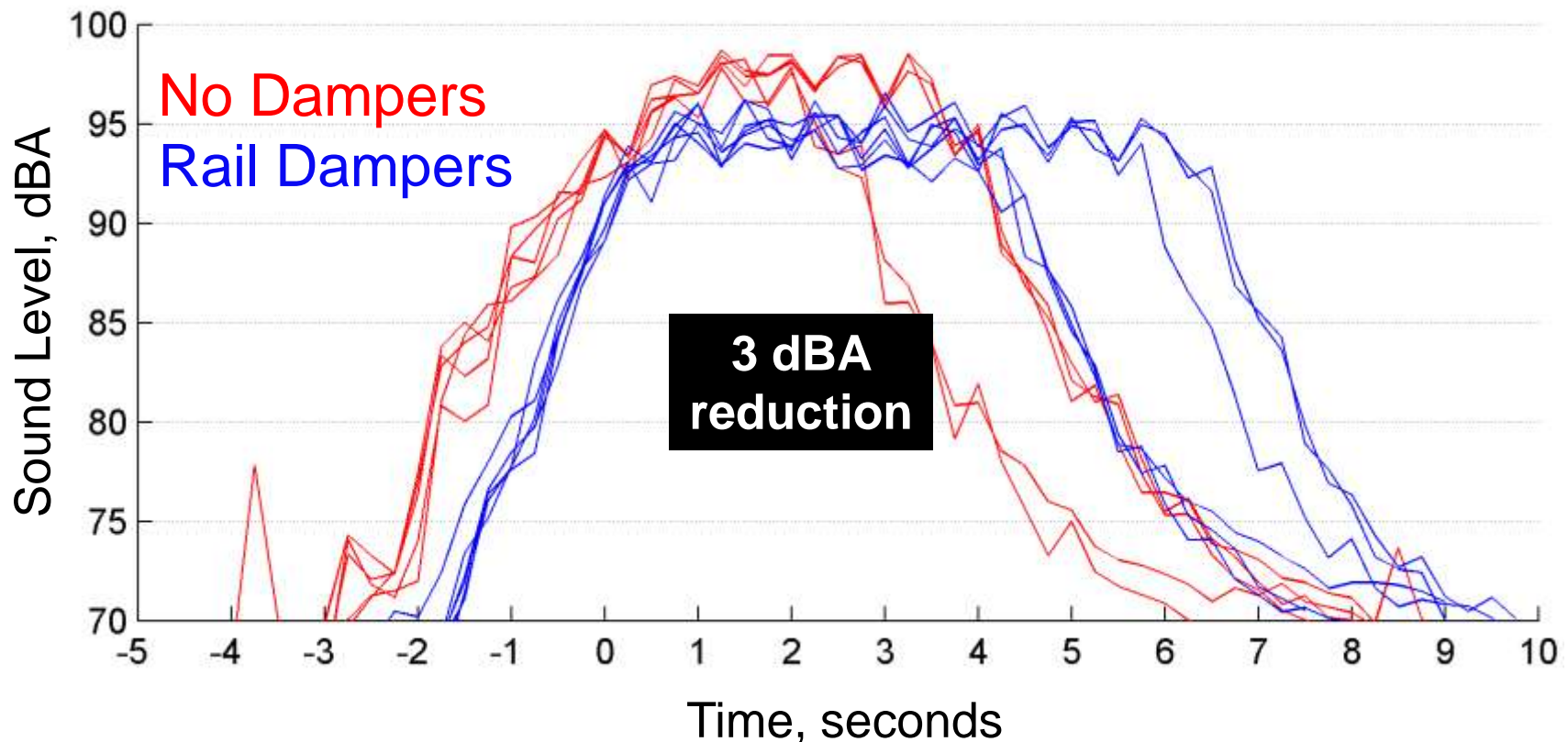


# Wayside Noise Setup

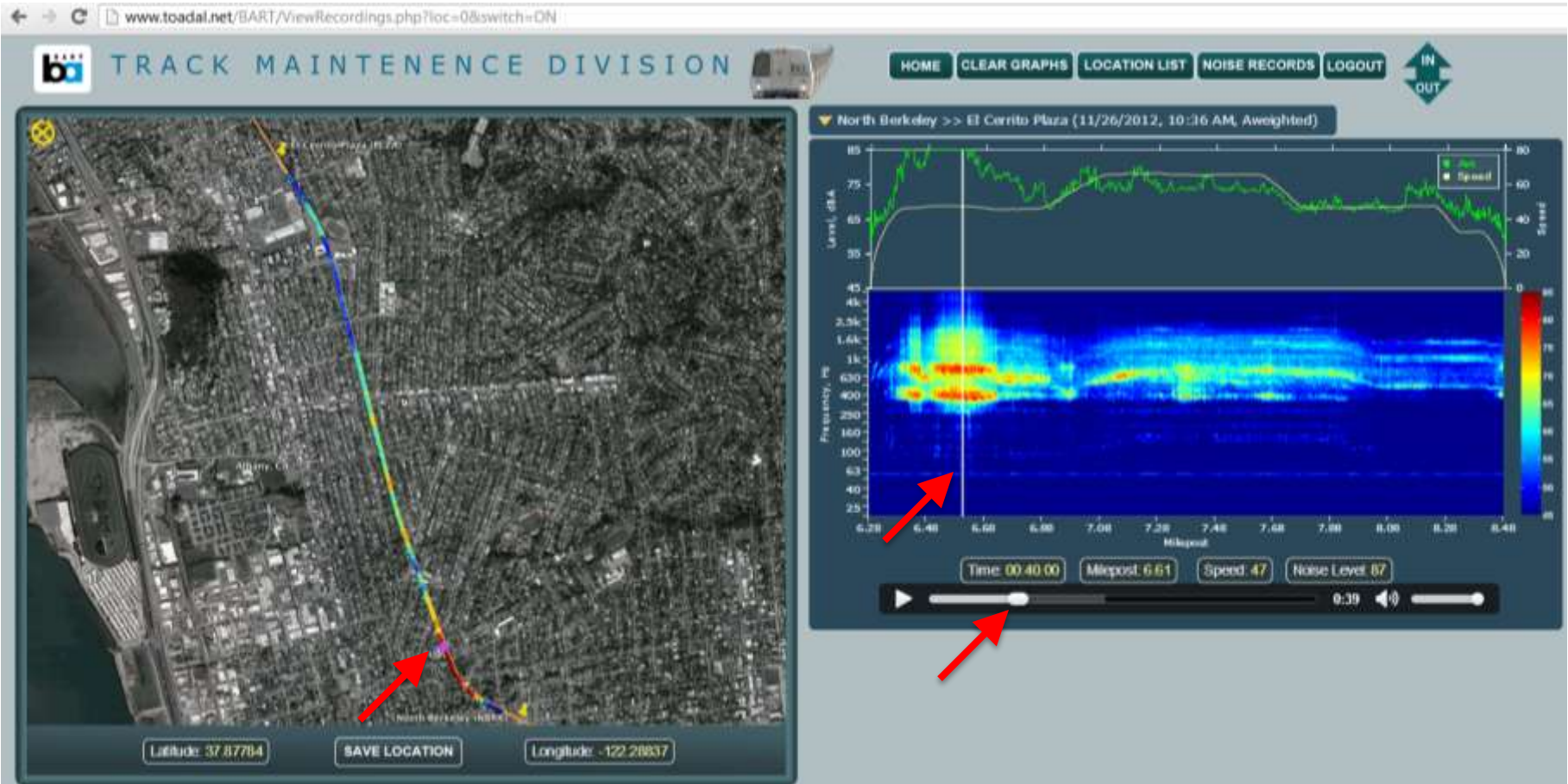


# Rail Dampers' Effectiveness Using Wayside Noise

Time Histories of Train Noise 7½ meters from rail



# Web App for BART



# Conclusions

- Tools for identifying and tracking corrugation and noise problems include:
  - On-board noise or vibration measurements
  - Rail roughness measurements
  - Wayside noise measurements 1m to 15m from track (3.3 ft to 50 ft)
- 3D, GIS, and animated displays:
  - Allow visualizing large quantities of data
  - Lead to insights
  - Help explain conclusions to non-technical audiences



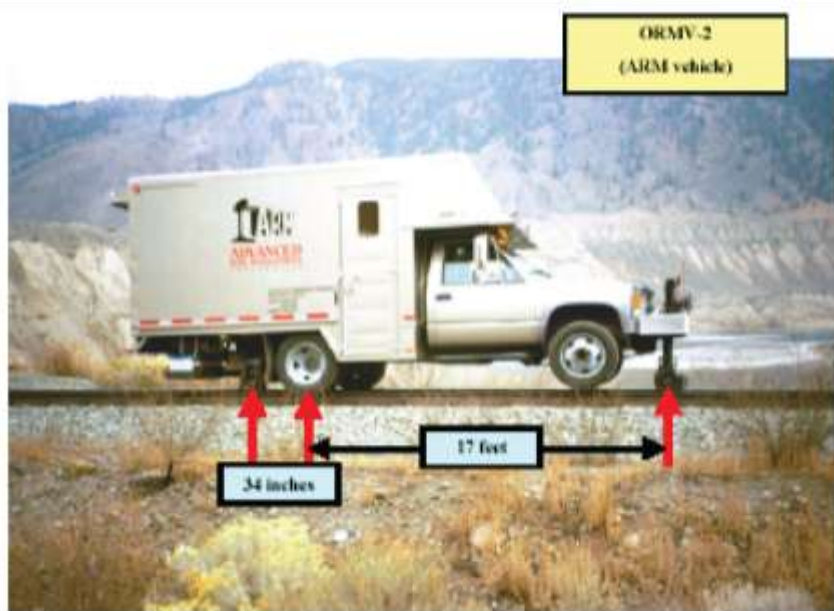
# Extensions to BART Web App

(joint effort by ATS, ARM and TOADAL.net)

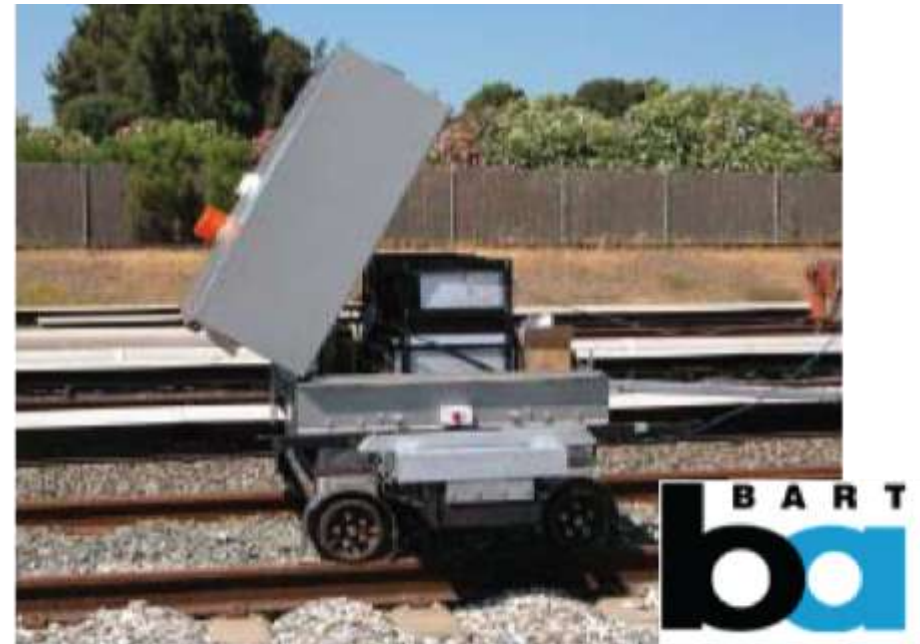
- Animation of Rangecam rail profile measurements
- Synchronize with relevant track data
- Links to other data (e.g., rail grinding database, complaints, ...)



# Track Geometry Measurements

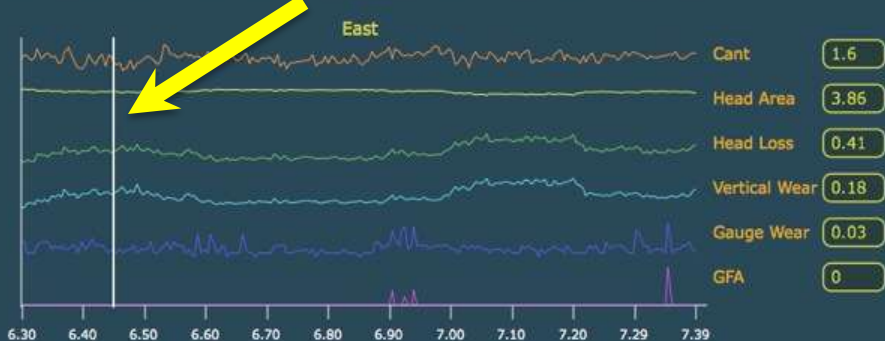
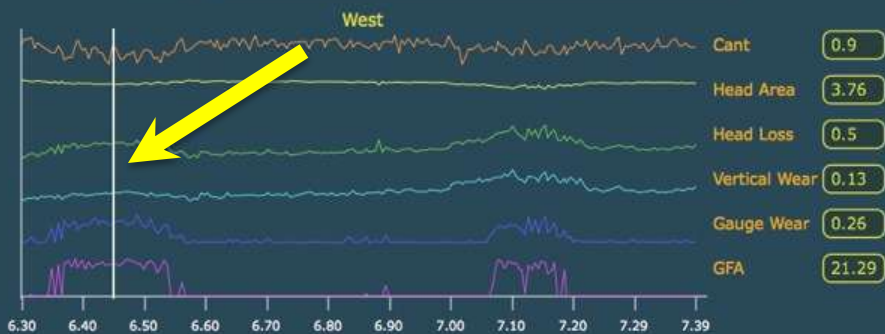
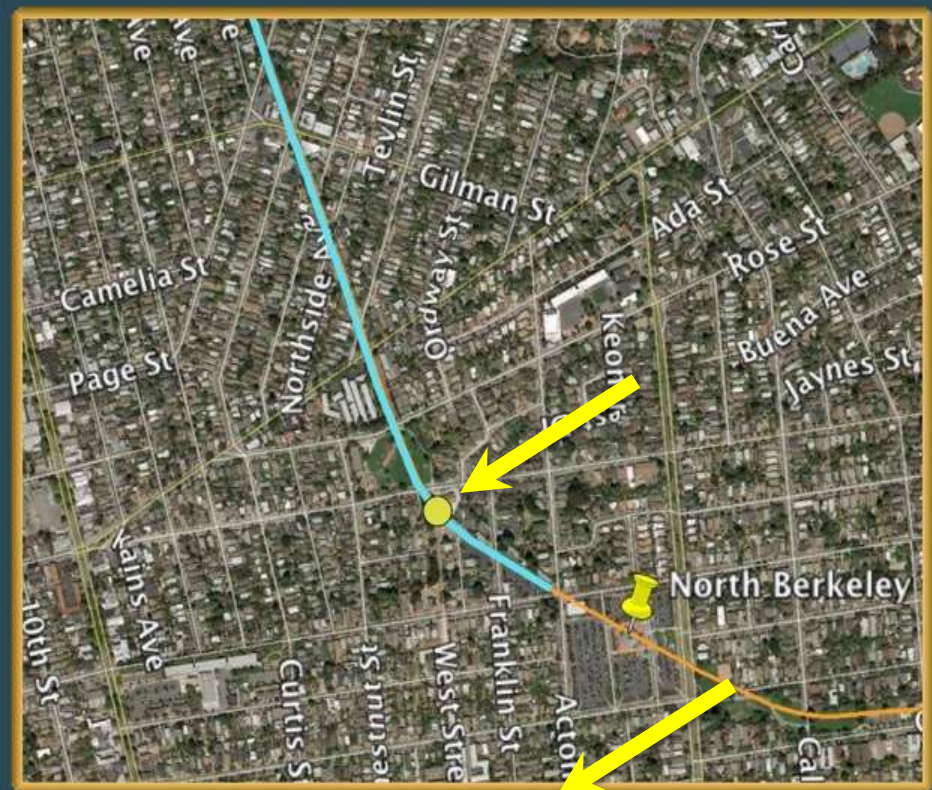


Vehicle Mount



Buggy Mount

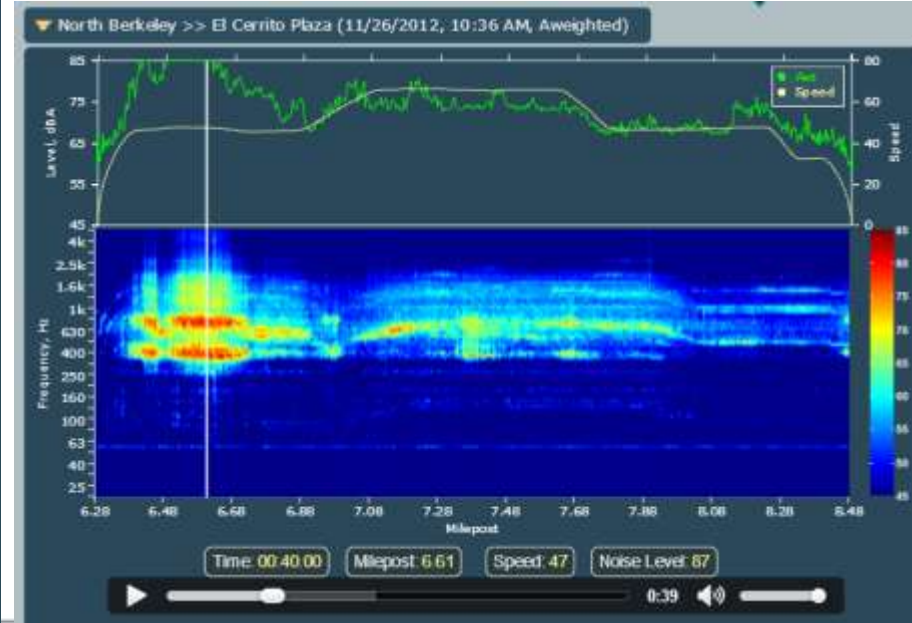
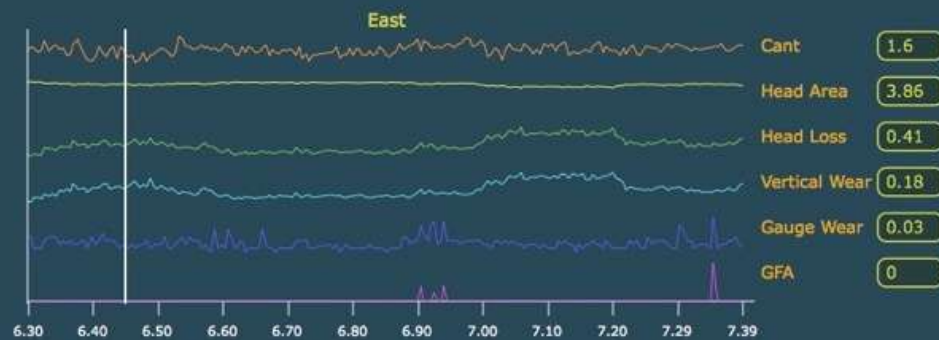
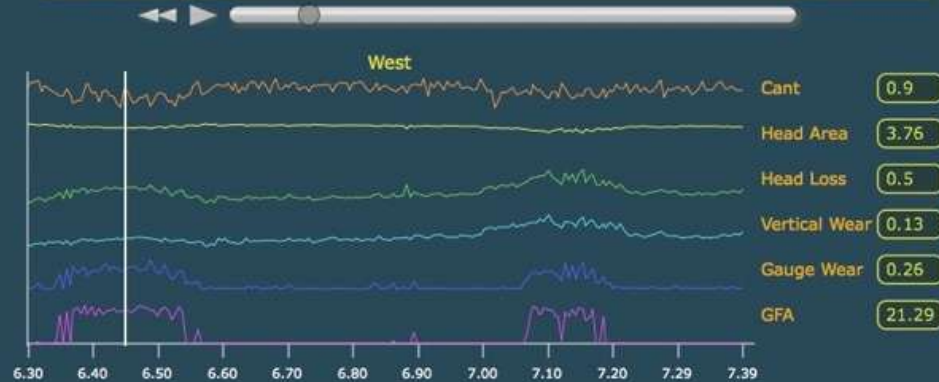




# RAIL PROFILE ANALYZER

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# Questions?

