Combining Onboard Noise Measurements with Other Data Sets to Characterize Track Condition

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ATSConsulting
acoustics, transportation + strategy

Outline

- Background of Onboard Noise Measurements at BART
  - Built Web App (CorrTracker) that is based on a MySQL database
  - Expanded database to incorporate other data sets
  - Contract to customize for Sound Transit
  - Is tool useful tool for State of Good Repair (SGR) programs?
- FTA Rule on SGR
- Introduction to CorrTracker
- Application of CorrTracker-type tools to SGR

Transit Asset Management; National Transit Database, Final Rule (July 26, 2016)

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49 CFR Parts 625 and 630
National Transit Database; Transit Asset Management; Final Rule; Notices; National Transit Database: Capital Asset Reporting; Transit Asset Management: Proposed Guidebooks

DEPARTMENT OF TRANSPORTATION

Federal Transit Administration

49 CFR Parts 625 and 630

[Docket No. FTA–2014–0020]

RIN 2132–AB07

management that will apply to all recipients and subrecipients of chapter 53 funds that own, operate, or manage public transportation capital assets. This final rule requires public transportation providers to develop and implement out transit asset management (TAM) plans. TAM plans must include an asset inventory, condition assessments of inventoried assets, and a prioritized list of investments to improve the state of good repair of their capital assets. This final rule also establishes state good repair standards and four state of good repair (SGR) performance measures. Transit providers are required to set performance targets for their capital assets based on the SGR measures and report their targets, as well as information related to the condition of their capital assets, to the National Transit Database.

DATES: Effective October 1, 2016.

FOR FURTHER INFORMATION CONTACT: For program matters, Mshadoni Smith, Office of Budget and Policy, (202) 366–4050 or *Mshadoni.Smith@dot.gov*. For legal matters, Candace Key, Office of Chief Counsel, (202) 366–4011 or *Candace.Key@dot.gov*.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Executive Summary

A. Purpose of Regulatory Action

This final rule establishes a National Transit Asset Management (TAM) System in accordance with section 20019 of the Moving Ahead for Progress in the 21st Century Act (MAP–21; Pub. L. 112–141 (2012), codified at 49 U.S.C. 5326).[1] A transit asset management system is ''a strategic and systematic process of operating, maintaining, and improving public transportation capital assets effectively through the life cycle of such assets.'' 49 U.S.C. 5326(a)(3).

Critical to the safety and performance of a public transportation system is the condition of its capital assets—most notably, its equipment, rolling stock, infrastructure, and facilities. When transit assets are not in a state of good repair, the consequences include increased safety risks, decreased system reliability, higher maintenance costs, and lower system performance.

Comprehensive quantitative information about the consequences of capital assets not being in a state of good repair is unavailable. However, insufficient funding combined with inadequate transit asset management practices have contributed to an estimated $85.9 billion transit state of good repair (SGR) backlog—a value derived from FTA's Transit Economic Requirements Model (TERM).[2] The SGR backlog is representative of the reinvestment cost to replace any transit assets whose condition is below the midpoint on TERM's 1 (poor) to 5 (excellent) scale, or 2.5. The SGR backlog poses a significant challenge during these fiscally constrained times, given FTA's estimates that an additional $2.5 billion per year above current funding levels from all levels of government is needed just to prevent the SGR backlog from growing.

The National TAM System is a scalable and flexible framework. The components of the National TAM System will work together to ensure that achieving and maintaining a state of good repair becomes, and remains, a top priority for transit providers, as well as States and Metropolitan Planning Organizations (MPOs).

B. Statutory Authority

Section 20019 of MAP–21 amended Federal transit law by adding a new section 5326 to Chapter 53 of title 49 of the United States Code. The provisions of 49 U.S.C. 5326 require the Secretary of Transportation to establish and implement a National TAM System which (1) defines the term state of good repair, (2) requires that all Chapter 53 recipients and subrecipients develop a TAM plan, (3) establishes annual reporting requirements, and (4) includes technical assistance. 49 U.S.C. 5326(b).

The Secretary also must establish SGR performance measures, and recipients must set performance targets based on the measures. 49 U.S.C. 5326(c)(1) and (2). Each designated recipient must submit two annual reports to the Secretary—one report on the condition of their recipients' public transportation systems, including a description of any change in condition since the last report, and another describing its recipients' progress towards meeting performance targets established during that fiscal year and a description of the recipients' performance targets for the subsequent fiscal year. 49 U.S.C. 5326 (b)(3) and 49 U.S.C. 5326(c)(3).[3]

C. Summary of Major Provisions

1. Transit Asset Management

This final rule adds a new part 625, ''Transit Asset Management,'' to title 49 of the Code of Federal Regulations (part 625). This rule implements the several statutory requirements of 49 U.S.C. 5326(b) and (c), referenced in the previous section, by coalescing them into a comprehensive National TAM

[1] On December 4, 2015, the President signed into law the Fixing America's Surface Transportation (''FAST'') Act (Pub. L. 114–94), which supersedes MAP–21; however, FAST made no amendments to the transit asset management statute at 49 U.S.C. 5326. This notice will refer to MAP–21 throughout the preamble.

[2] Individual transit agencies were not involved in developing the assessment of the $85.9 billion state of good repair backlog. FTA developed the estimate by feeding combined data into TERM. TERM produces national-level estimates of the national state of good repair backlog, based on an underlying set of models relating the expected average true condition of an asset to the asset's age. Currently, FTA does not collect the systematic data necessary to do a detailed time-series analysis on whether the

[3] The term ''designated recipient'' is defined in statute as ''(A) an entity designated,

Key Points in FTA SGR Rule

- Establishes minimum requirements for asset management
- Applies to all recipients of chapter 53 funds for public transportation

Rule Requires Public Transit Systems

- To develop and implement a Transit Asset Management (TAM) plan that includes
  - an asset inventory
  - condition assessments of inventoried assets, and
  - a prioritized list of investments to improve the state of good repair.

Transit systems must :

- Set asset performance targets based on the SGR measures
- The targets and condition the assets must be reported to the National Transit Database

FTA guidance on fixed-guideway SGR

The performance measure for rail fixed-guideway, track, signals, and systems is the percentage of track segments with performance restrictions.

Translation: Number of slow orders

SGR for Track as Defined by FTA, Number of Slow Orders

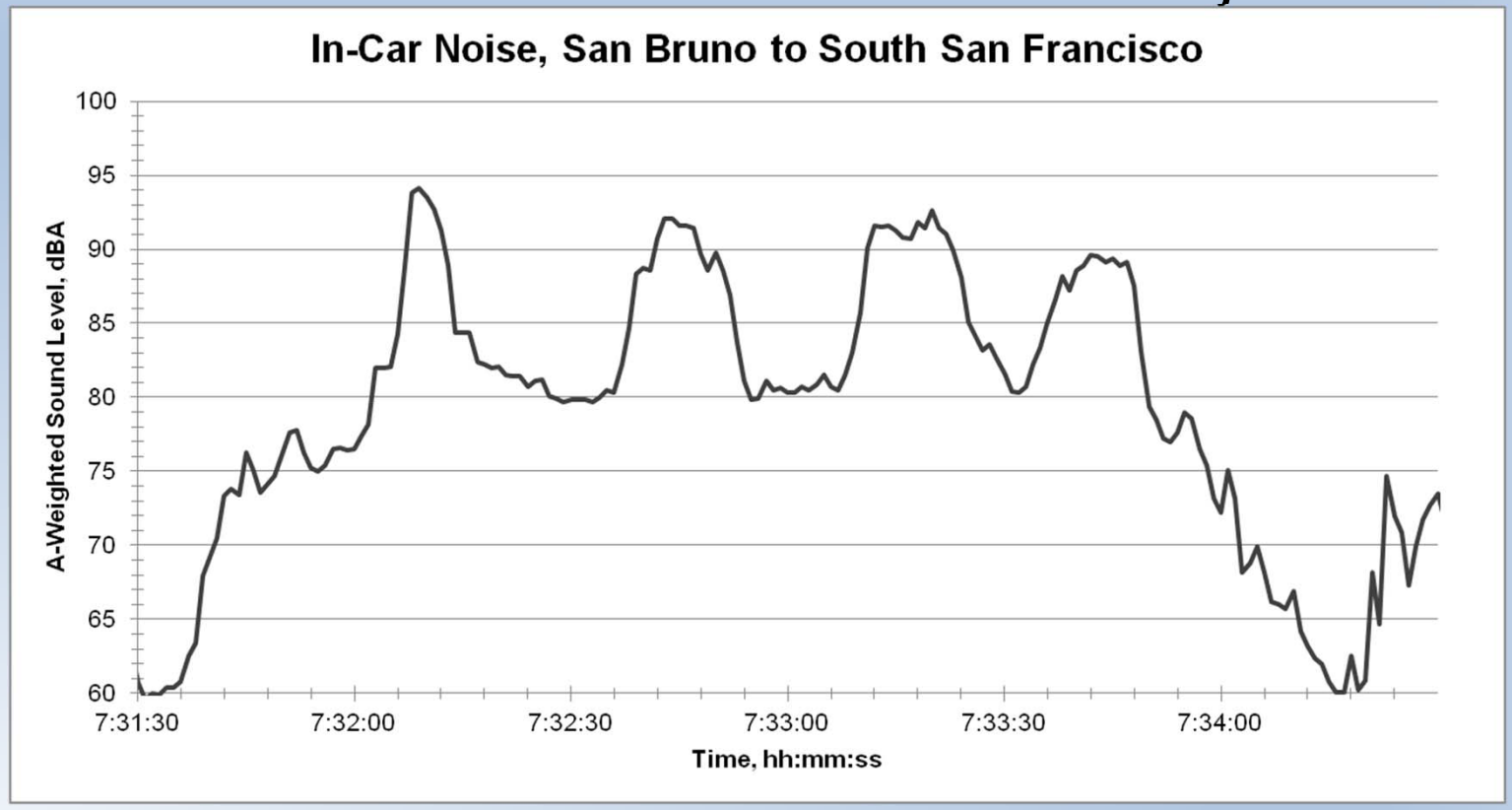
- Defined by number of slow orders
- Fewer slow orders ➔ better SGR
- Does not provide guidance to maintenance staff
- Does eliminating all slow orders reduce the odds of receiving FTA funding???

CorrTracker Background

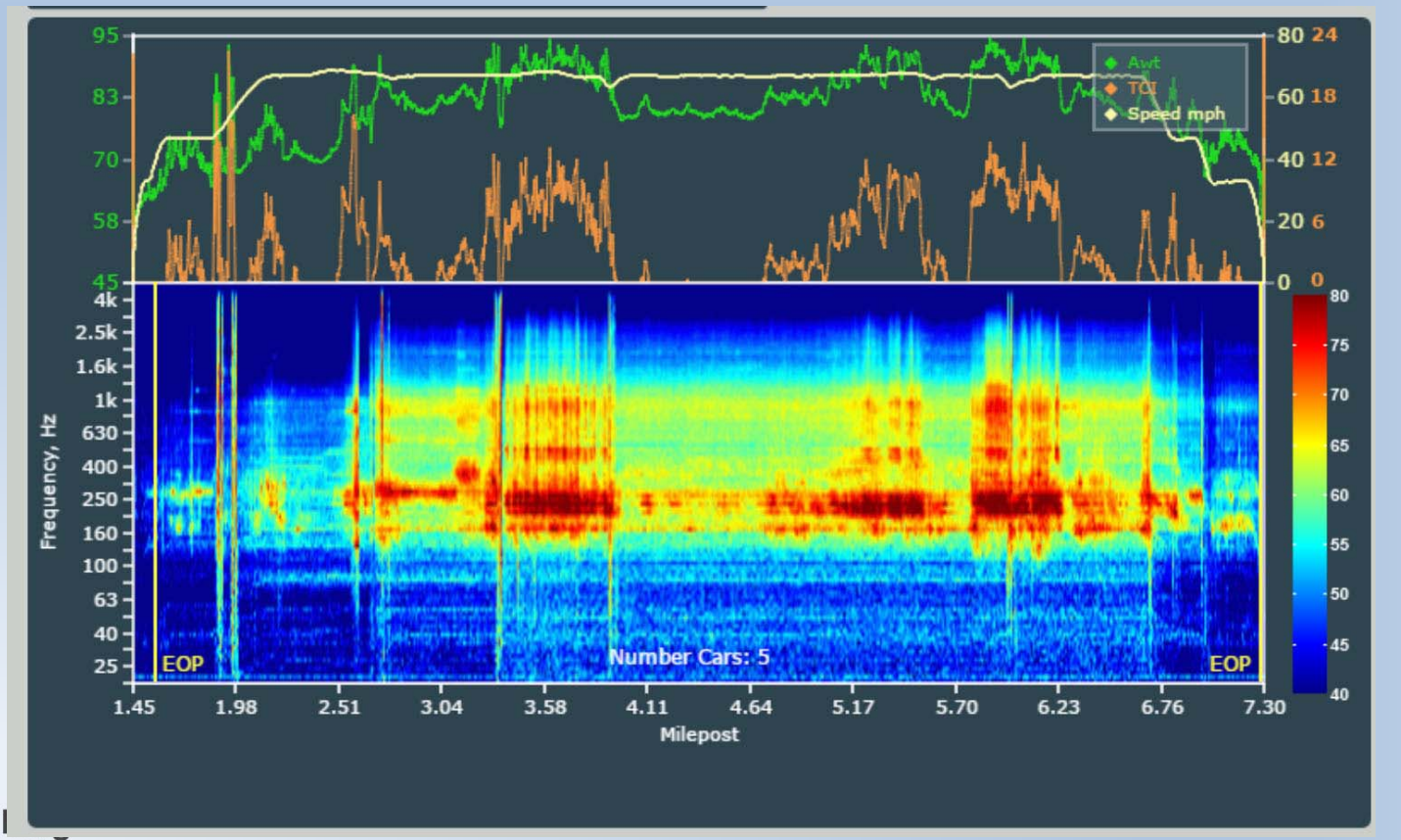
- Initially used at BART to prioritize rail grinding
  - Provided BART staff with PDFs of station-to-station noise spectrograms plus speed data
  - At the request of BART staff, ATS prepared a web app (**CorrTracker**) to store and display data
- Have been measuring BART systemwide at 6-month intervals since 2012
- In late 2016 contracted with Sound Transit to provide a customized version of CorrTracker
- Have used the data to investigate issues other than corrugation.

Rail Corrugation

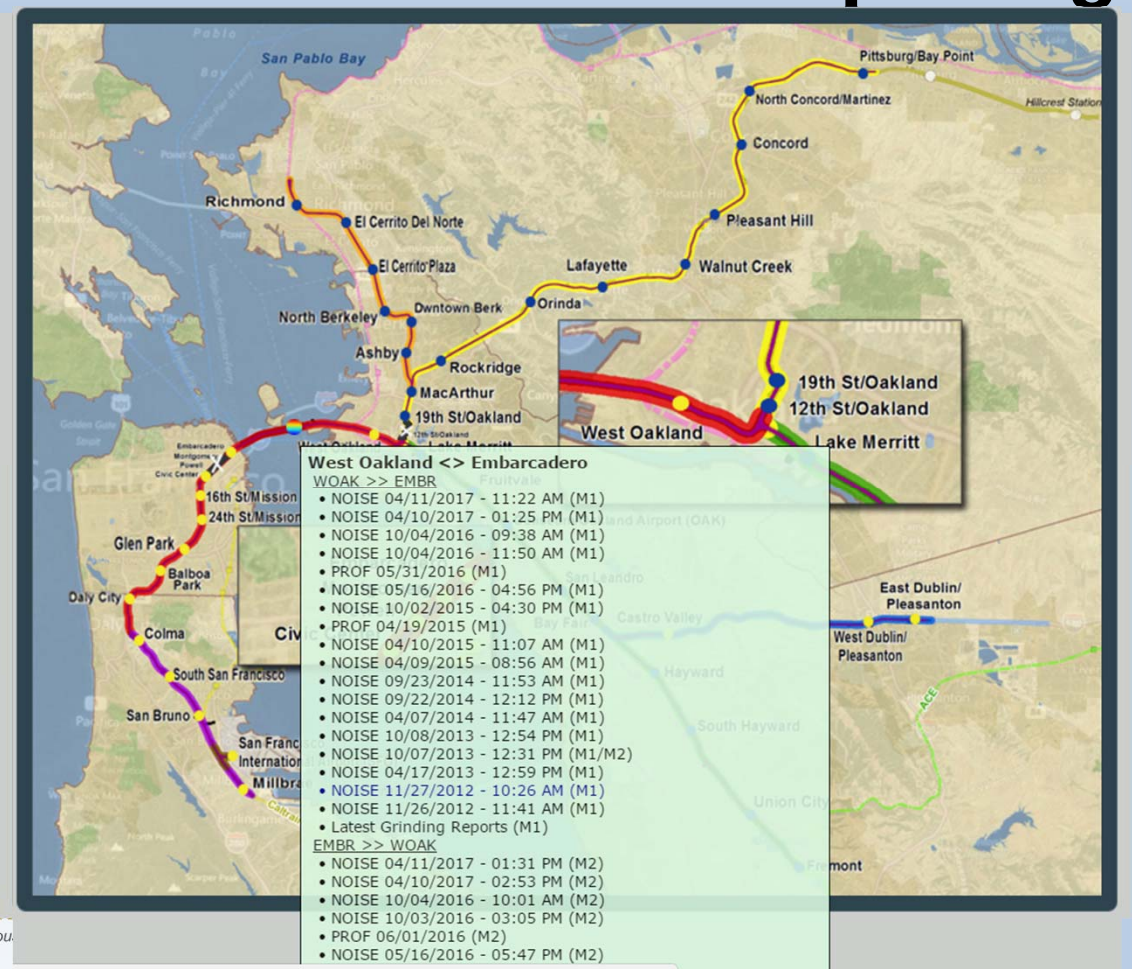
On-Board Noise Measurement, 2003



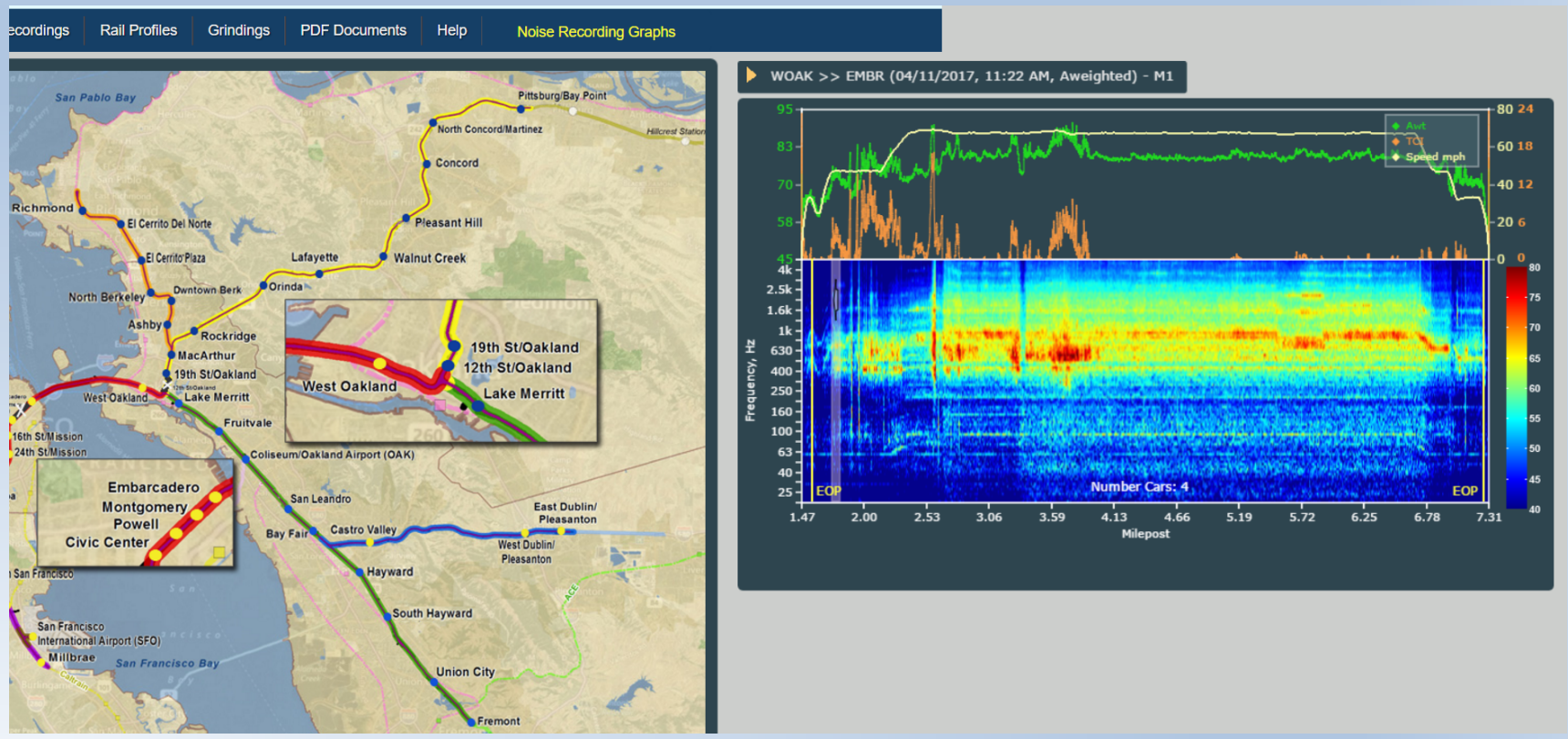
Example Station-to-Station Spectrogram



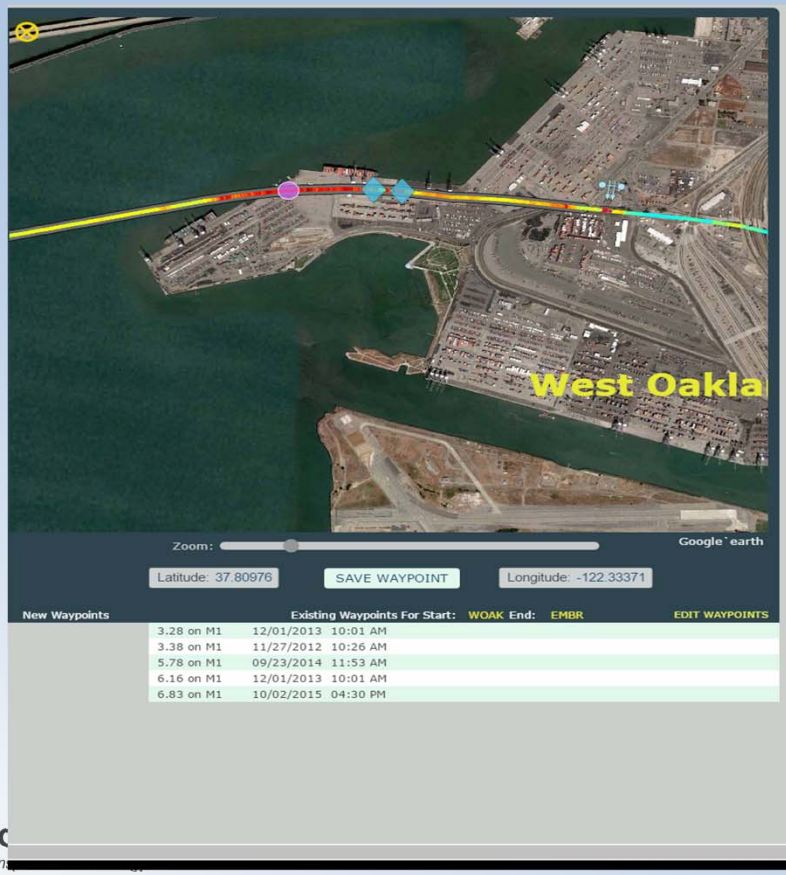
CorrTracker: Opening Screen

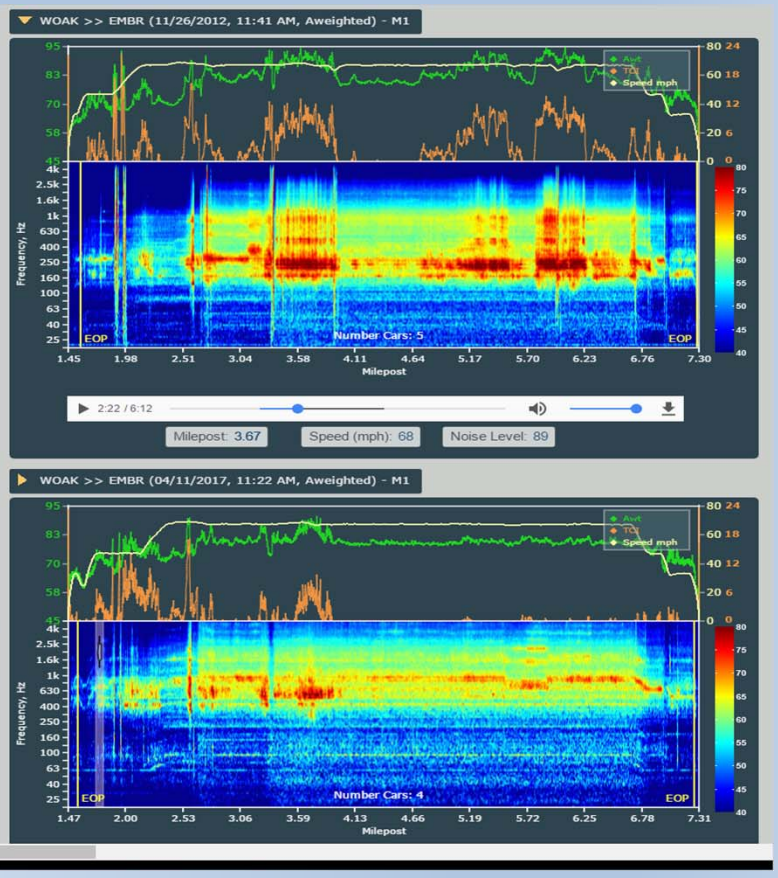


CorrTracker: Selected Measurement



CorrTracker: Two Measurements





CorrTracker: Tabular Displays (2012)

Action	Segment Abbrv	Station Start	Station Stop	Route	Vehicle Type	Vehicle Number	Num Cars	Track	Date	Time	Avg Awt	Total Miles	Noise Rating	STATION START >> Corrugation Along Track << STATION STOP
View Graph	WOAK<=>EMBR	WOAK	EMBR	Dublin to Daly City	C	316	10	M1	11/27/2012	10:26 AM	83.31	5.87		
View Graph	24TH<=>GLEN	GLEN	24TH	Millbrae to Richmond	C	378	5	M2	11/26/2012	12:52 PM	82.76	1.65		
View Graph	24TH<=>GLEN	24TH	GLEN	Dublin to Daly City	C	316	10	M1	11/27/2012	10:40 AM	82.49	1.65		
View Graph	24TH<=>GLEN	GLEN	24TH	Millbrae to Pittsburg	C	312	10	M2	11/27/2012	11:45 AM	82.37	1.65		
View Graph	CIVC<=>16TH	16TH	CIVC	Millbrae to Pittsburg	C	312	10	M2	11/27/2012	11:50 AM	82.07	1.11		
View Graph	24TH<=>GLEN	24TH	GLEN	Richmond to Millbrae	C	438Y	5	M1	11/26/2012	11:57 AM	81.37	1.65		
View Graph	WOAK<=>EMBR	WOAK	EMBR	Richmond to Millbrae	C	438Y	5	M1	11/26/2012	11:41 AM	81.26	5.87		
View Graph	POWL<=>CIVC	CIVC	POWL	Millbrae to Richmond	C	378	5	M2	11/26/2012	12:59 PM	81.11	0.53		
View Graph	WOAK<=>EMBR	EMBR	WOAK	Millbrae to Pittsburg	C	312	10	M2	11/27/2012	11:57 AM	80.78	5.87		
View Graph	SSAN<=>SBRN	SBRN	SSAN	Millbrae to Richmond	C	378	5	W2	11/26/2012	12:37 PM	80.76	2.41		
View Graph	POWL<=>CIVC	CIVC	POWL	Millbrae to Pittsburg	C	312	10	M2	11/27/2012	11:52 AM	80.49	0.53		
View Graph	12TH<=>19TH	12TH	19TH	Millbrae to Pittsburg	C	312	10	CX	11/27/2012	12:08 PM	80.48	0.36		
View Graph	16TH<=>24TH	16TH	24TH	Dublin to Daly City	C	316	10	M1	11/27/2012	10:38 AM	80.32	0.89		
View Graph	SSAN<=>SBRN	SSAN	SBRN	Richmond to Millbrae			0	W1	11/27/2012	11:06 AM	80.11	2.41		
View Graph	CIVC<=>16TH	16TH	CIVC	Millbrae to Richmond	C	378	5	M2	11/26/2012	12:57 PM	80.09	1.11		
View Graph	WOAK<=>EMBR	EMBR	WOAK	Millbrae to Richmond	C	378	5	M2	11/26/2012	1:04 PM	80.09	5.87		
View Graph	COLM<=>SSAN	COLM	SSAN	Richmond to Millbrae			0	W1	11/27/2012	11:03 AM	80.09	1.94		
View Graph	16TH<=>24TH	24TH	16TH	Millbrae to Richmond	C	378	5	M2	11/26/2012	12:55 PM	79.97	0.89		
View Graph	GLEN<=>BALB	BALB	GLEN	Millbrae to Richmond	C	378	5	M2	11/26/2012	12:50 PM	79.50	1.15		
View Graph	COLM<=>SSAN	COLM	SSAN	Richmond to Millbrae	C	438Y	5	W1	11/26/2012	12:10 PM	79.43	1.94		
View Graph	16TH<=>24TH	24TH	16TH	Millbrae to Pittsburg	C	312	10	M2	11/27/2012	11:48 AM	79.32	0.89		
View Graph	GLEN<=>BALB	BALB	GLEN	Millbrae to Pittsburg	C	312	10	M2	11/27/2012	11:43 AM	79.05	1.15		
View Graph	CIVC<=>16TH	CIVC	16TH	Dublin to Daly City	C	316	10	M1	11/27/2012	10:36 AM	78.82	1.11		
View Graph	DBRK<=>NBRK	DBRK	NBRK	Fremont to Richmond	A	1245	8	R1	11/26/2012	10:34 AM	78.64	1.05		
View Graph	MONT<=>POWL	POWL	MONT	Millbrae to Richmond	C	378	5	M2	11/26/2012	1:01 PM	78.63	0.42		
View Graph	SBRN<=>MLBR	MLBR	SBRN	Millbrae to Richmond	C	378	5	W2	11/26/2012	12:32 PM	78.47	3.04		
View Graph	16TH<=>24TH	16TH	24TH	Richmond to Millbrae	C	438Y	5	M1	11/26/2012	11:55 AM	78.43	0.89		

CorrTracker: Tabular Displays (2017)

Action	Segment Abbrv	Station Start	Station Stop	Route	Vehicle Type	Vehicle Number	Num Cars	Track	Date	Time	Avg Awt	Total Miles	Noise Rating	STATION START >> Corrugation Along Track << STATION
View Graph	24TH<=>GLEN	GLEN	24TH	Millbrae to Pittsburg	C	359	5	M2	04/11/2017	01:17 PM	82.26	1.65		
View Graph	CIVC<=>16TH	16TH	CIVC	Millbrae to Pittsburg	C	359	5	M2	04/11/2017	01:22 PM	80.06	1.11		
View Graph	16TH<=>24TH	24TH	16TH	Millbrae to Pittsburg	C	359	5	M2	04/11/2017	01:20 PM	79.58	0.89		
View Graph	24TH<=>GLEN	24TH	GLEN	Dublin to Daly City	C	391	4	M1	04/11/2017	11:38 AM	78.92	1.65		
View Graph	SSAN<=>SBRN	SBRN	SSAN	Millbrae to Pittsburg	C	359	5	W2	04/11/2017	01:00 PM	78.75	2.41		
View Graph	COLM<=>SSAN	SSAN	COLM	Millbrae to Pittsburg	C	359	5	W2	04/11/2017	01:04 PM	77.17	1.94		
View Graph	24TH<=>GLEN	24TH	GLEN	Richmond to Millbrae	C	2571	3	M1	04/10/2017	01:40 PM	76.92	1.65		
View Graph	ROCK<=>ORIN	ORIN	ROCK	Pittsburg to SFO	C	2520	10	C2	04/11/2017	03:03 PM	76.92	4.42		
View Graph	WOAK<=>EMBR	WOAK	EMBR	Richmond to Millbrae	C	2571	3	M1	04/10/2017	01:25 PM	76.87	5.87		
View Graph	ROCK<=>ORIN	ROCK	ORIN	Millbrae to Pittsburg	C	359	5	C1	04/11/2017	01:50 PM	76.74	4.42		
View Graph	SSAN<=>SBRN	SSAN	SBRN	Pittsburg to SFO	C	418	5	W1	04/11/2017	12:05 PM	76.24	2.41		
View Graph	WOAK<=>EMBR	EMBR	WOAK	Millbrae to Pittsburg	C	359	5	M2	04/11/2017	01:31 PM	76.13	5.87		
View Graph	CIVC<=>16TH	16TH	CIVC	Daly City to Fremont	C	2540	3	M2	04/10/2017	02:47 PM	75.75	1.11		
View Graph	16TH<=>24TH	24TH	16TH	Daly City to Fremont	C	2540	3	M2	04/10/2017	02:45 PM	75.62	0.89		
View Graph	WOAK<=>EMBR	WOAK	EMBR	Dublin to Daly City	C	391	4	M1	04/11/2017	11:22 AM	75.55	5.87		
View Graph	24TH<=>GLEN	GLEN	24TH	Daly City to Fremont	C	2540	3	M2	04/10/2017	02:43 PM	75.49	1.65		
View Graph	SSAN<=>SBRN	SSAN	SBRN	Richmond to Millbrae	C	2571	3	W1	04/10/2017	01:55 PM	75.33	2.41		
View Graph	WOAK<=>EMBR	EMBR	WOAK	Daly City to Fremont	C	2540	3	M2	04/10/2017	02:53 PM	75.16	5.87		
View Graph	DBRK<=>NBRK	NBRK	DBRK	Richmond to Millbrae	C	2571	3	R2	04/10/2017	01:03 PM	75.11	1.05		
View Graph	GLEN<=>BALB	BALB	GLEN	Millbrae to Pittsburg	C	359	5	M2	04/11/2017	01:15 PM	74.82	1.15		
View Graph	COLM<=>SSAN	COLM	SSAN	Pittsburg to SFO	C	418	5	W1	04/11/2017	12:02 PM	74.69	1.94		
View Graph	COLM<=>SSAN	COLM	SSAN	Richmond to Millbrae	C	2571	3	W1	04/10/2017	01:52 PM	74.47	1.94		
View Graph	12TH<=>WOAK	WOAK	12TH	Millbrae to Pittsburg	C	359	5	M2/MX/CX	04/11/2017	01:39 PM	74.07	1.59		
View Graph	SBRN<=>MLBR	SBRN	MLBR	Richmond to Millbrae	C	2571	3	W1	04/10/2017	01:58 PM	73.51	3.04		
View Graph	SSAN<=>SBRN	SBRN	SSAN	Millbrae to Pittsburg	C	2540	3	W2	04/10/2017	02:27 PM	73.04	2.41		
View Graph	12TH<=>19TH	12TH	19TH	Millbrae to Pittsburg	C	359	5	CX	04/11/2017	01:42 PM	72.86	0.36		
View Graph	CIVC<=>16TH	CIVC	16TH	Richmond to Millbrae	C	2571	3	M1	04/10/2017	01:36 PM	72.74	1.11		
View Graph	ASHB<=>DBRK	DBRK	ASHB	Richmond to Millbrae	C	2571	3	R2	04/10/2017	01:05 PM	72.43	1.20		
View Graph	ASHB<=>DBRK	ASHB	DBRK	Fremont to Richmond	C	2540	3	R1	04/10/2017	12:19 PM	72.29	1.20		
View Graph	NBRK<=>PLZA	PLZA	NBRK	Richmond to Millbrae	C	2571	3	R2	04/10/2017	01:00 PM	71.84	2.23		

CorrTracker, Grinding Priorities

Based On Most Recent Sound Level Measurements on Dates 04/10/2017, 04/11/2017

Export Grinding Priorities List

Action		TCI Rating	Priority	Date	Max Tci	Integral	Depart Stat	Arrive Stat	B mp	E mp	Track	Length	Avg Speed mph	Avg Awt	Structures	Status
Grinding Comparisons	Remove Priority		1	04/11/2017	18.8	3.7	CONC	NCON	22.117	22.826	C1	3744	67	80.2	Aerial,Surface	Not Ground
Grinding Comparisons	Remove Priority		2	04/11/2017	18.8	3.6	19TH	MCAR	0.746	1.074	CX	1736	33	88.1	Subway	Not Ground
Grinding Comparisons	Remove Priority		3	04/11/2017	18.3	2.2	SSAN	COLM	17.008	17.346	W2	1783	40	83.7	Subway,Surface	Not Ground
Grinding Comparisons	Remove Priority		4	04/11/2017	16.7	14.5	GLEN	24TH	10.871	12.231	M2	7177	54	91.0	Subway	Not Ground
Grinding Comparisons	Remove Priority		5	04/11/2017	16.2	13.5	ORIN	ROCK	5.068	7.366	C2	12132	65	87.9	Subway	Not Ground
Grinding Comparisons	Remove Priority		6	04/11/2017	16.2	9.3	16TH	CIVC	8.722	9.690	M2	5114	44	88.6	Subway	Not Ground
Grinding Comparisons	Remove Priority		7	04/11/2017	16.0	8.6	SFIA	SBRN	21.213	22.358	Y2	6045	30	76.3	Surface	Not Ground
Grinding Comparisons	Remove Priority		8	04/11/2017	15.8	3.8	BALB	GLEN	12.517	12.836	M2	1685	47	90.9	Surface,Subway	Not Ground
Grinding Comparisons	Remove Priority		9	04/10/2017	15.0	2.0	BALB	GLEN	12.567	12.845	M2	1469	41	83.0	Surface,Subway	Not Ground
Grinding Comparisons	Remove Priority		10	04/11/2017	15.7	1.9	WOAK	12TH	0.250	0.421	MX	899	32	87.0	Subway	Not Ground
Grinding Comparisons	Remove Priority		11	04/11/2017	15.8	1.1	WOAK	EMBR	2.407	2.673	M1	1402	69	80.2	Surface,Subway	Not Ground
Grinding Comparisons	Remove Priority		12	04/11/2017	14.4	8.1	24TH	16TH	9.834	10.570	M2	3886	43	88.9	Subway	Not Ground
Grinding Comparisons	Remove Priority		13	04/11/2017	14.1	8.0	24TH	GLEN	11.275	12.221	M1	4996	51	88.2	Subway	Not Ground

Grinding Priorities. TCI used to find regions of track to grind. Prioritize by a combination of max TCI in region and the length of exceedance.

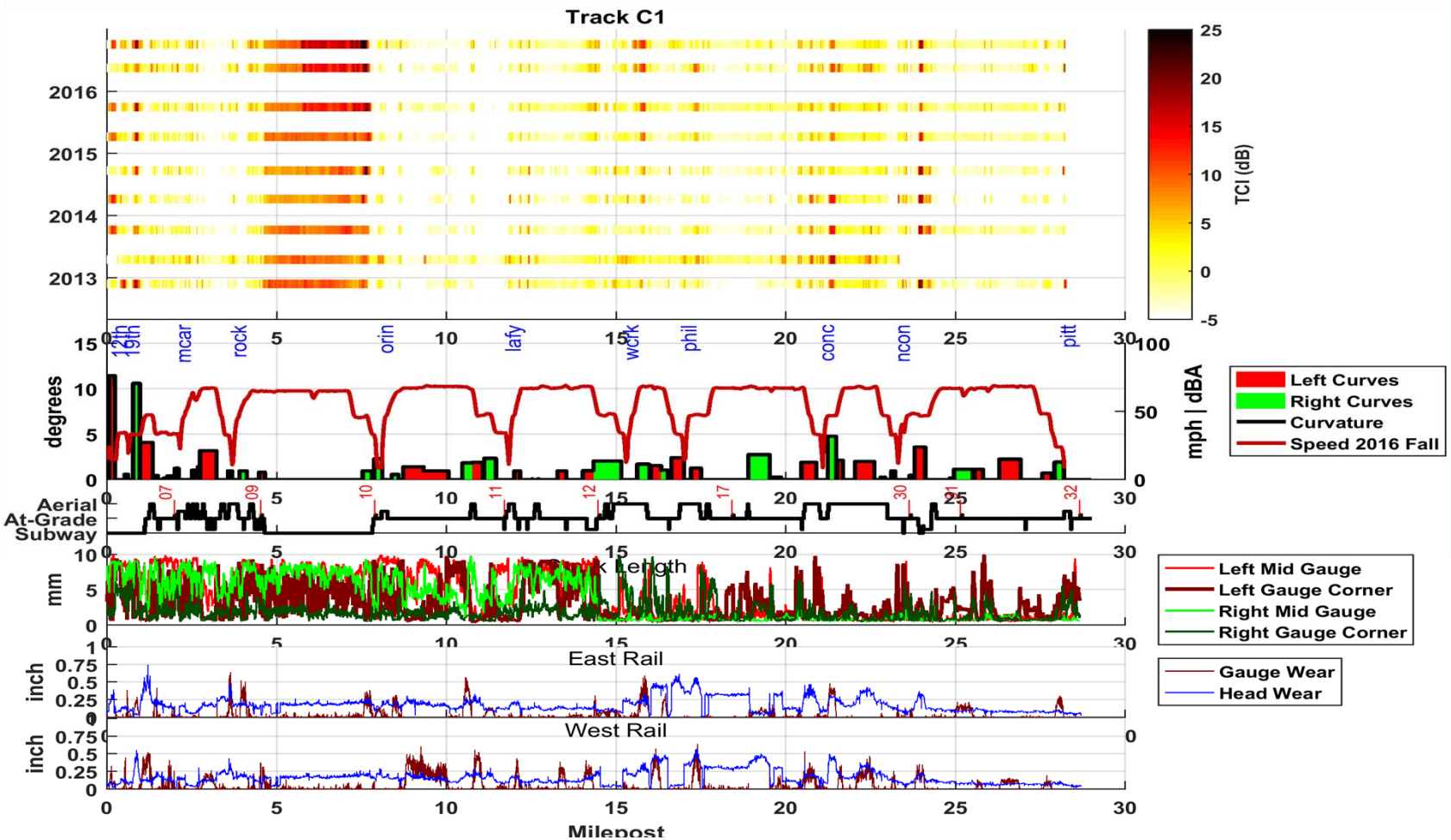
Other Data Types

- Track fault measurements
  - (e.g. Sperry Ultrasoinc Measurements)
- Rail profile measurements
  - (e.g. Holland Rangecam software)
- Database of rail grinding
- Database of track maintenance
- Rolling Contact Fatigue (RCF) measurements

Application to New Wheel Profile at BART

- Display multiple types of data on “track chart” type display
  - MATLAB charts
- Identified 50 locations that will be watched as new profiles are introduced
- Criteria for selecting monitoring sites
  - Locations where historically have had corrugation or other problems.
  - Variety of structures and track types.

Onboard Noise (Matlab Display)



Extensions for Sound Transit

- TCI for rolling noise and curve noise (squeal and flanging)
- RFID tags at ends of station platforms
- Investigating applications to State of Good Repair
  - Question is whether CorrTracker can be used as a “performance measure”.

Qualitative vs. Quantitative Measures

- “Qualitative” example: visual track inspections.
- Quantitative includes all the various means of measuring track features (e.g. profiles, rail wear, gauge, ultrasonic fault measurements, …

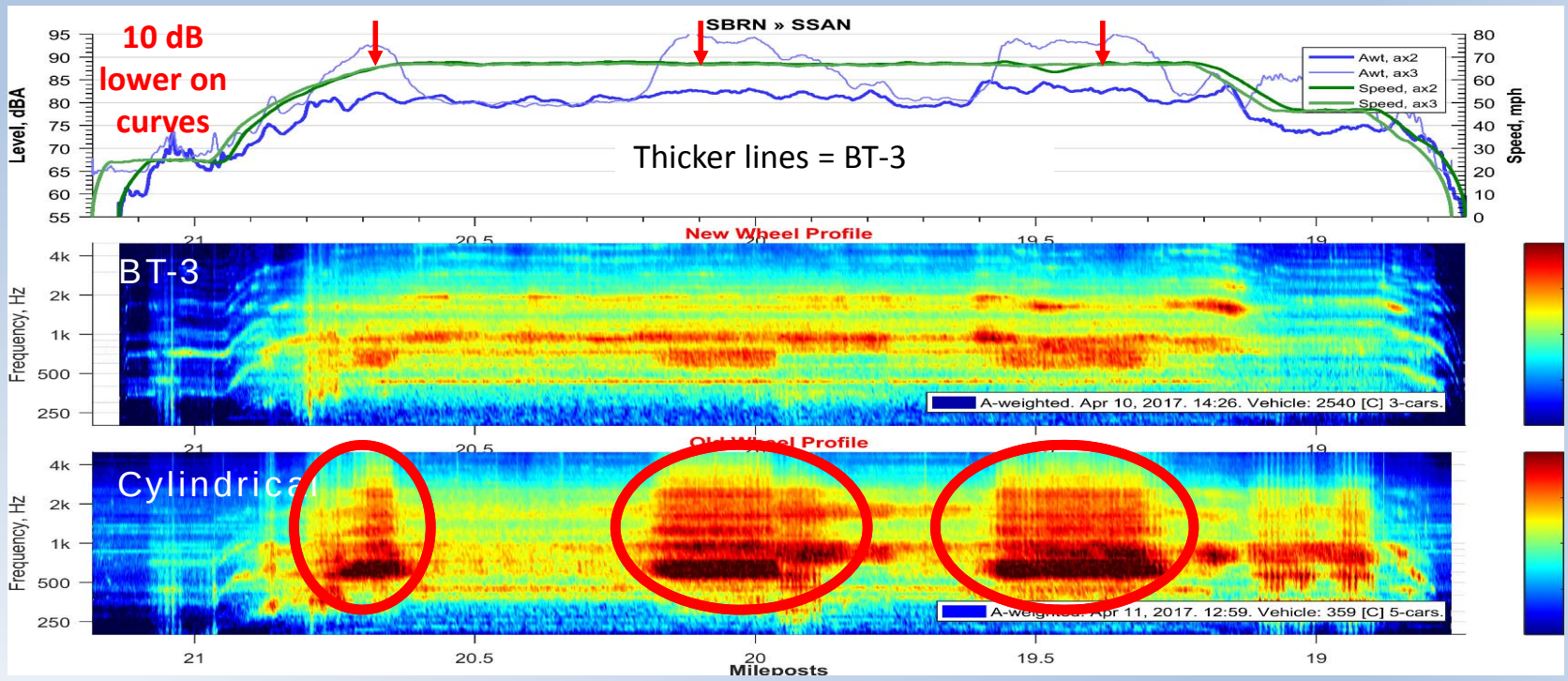
SGR wants a number

- Measure
- Analyze
- Displays to illustrate
  - Note that different displays are appropriate for different audiences.
  - Relatively untechnical displays for management and directors
  - Technical displays to help engineers identify trends and maintenance staff see what needs to be done
- Metric(s) based on measurements

Bonus: Comparison of new and old wheel profiles at BART

- Onboard noise can be quick measure to compare how well a new wheel profile performs acoustically.
- Example: comparison of BART's existing cylindrical wheels to a new profile that is more conical (BT-3).

BONUS: Comparison of new and old wheel profiles at BART



Cylindrical vs BT-3 Wheel Profile

Filters	Percentage of subgroup where BT-3 Wheels are quieter
None (Speed >= 15)	66 %
Speed >= 25	66 %
Speed >= 35	65 %
Speed >= 45	65 %
Speed >= 55	65 %
Speed >= 65	65 %

Filters	Percentage of subgroup where BT-3 Wheels are quieter
Tangents	64 %
Curves	68 %
Curves > 1 degrees (5729')	68 %
Curves > 2 degrees (2864')	56 %
Curves > 3 degrees (1909')	52 %
Curves > 5 degrees (1145')	98 %
Curves > 7 degrees (817')	100 %

1. 2/3 of track: BT-3 is quieter, but 1/3 of track BT-3 is louder.
2. 2/3 is true whether tangent or curves except:
3. 100% of 5 degree or greater curves are quieter with BT-3.

Thank you!

Questions…