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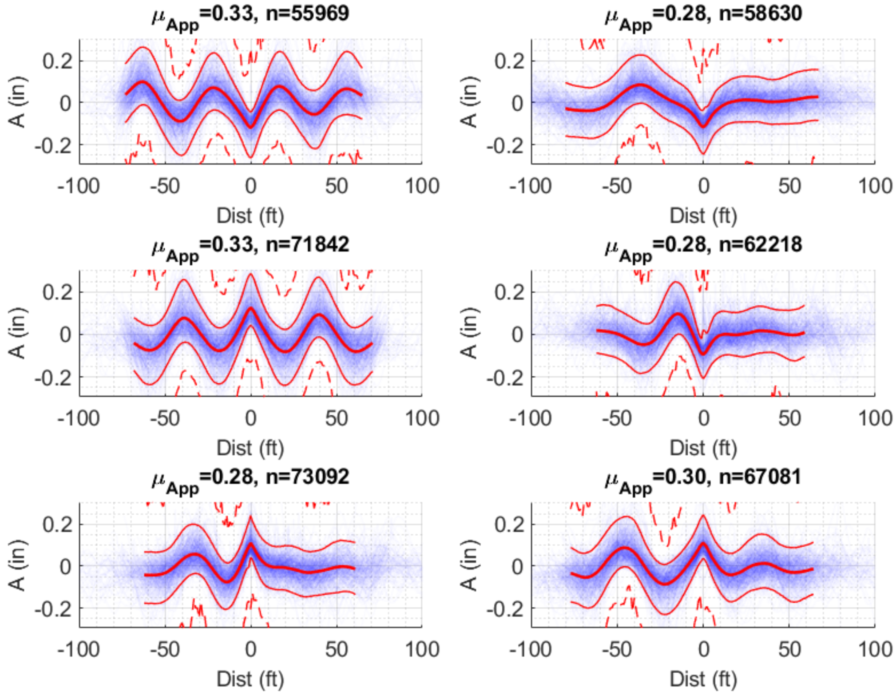
Washington, DC 20590

Characterization of Track Geometry for Various Operational Conditions



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14. ABSTRACT
This report characterizes the amplitude and wavelength content of the current track geometry environment of the United States railroad system and examines the combination of geometric parameters for different operational conditions. The analyzed track geometry dataset consists of over 49,000 miles of track in the United States, measured between 2012 and 2019. The types of characterization used in this study include statistical, frequency-based, and clustering analyses. The single-variable and bivariate statistical tables in this report can be used to estimate the likelihood of encountering alignment and surface irregularities or combinations of the two of any given magnitude in various FRA track classes. The typical irregularity shapes identified by means of clustering can be used in further track geometry studies to determine the shapes most detrimental to the vehicle-track system's safety. A combination of the statistical tables and clustering analysis can be used to construct artificial combined track geometries for further study and as an input to vehicle-track interaction simulation models.

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Track geometry, track quality, track irregularities, space curve, Automated Track Inspection Program, ATIP, Power Spectral Density, PSD, clustering.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

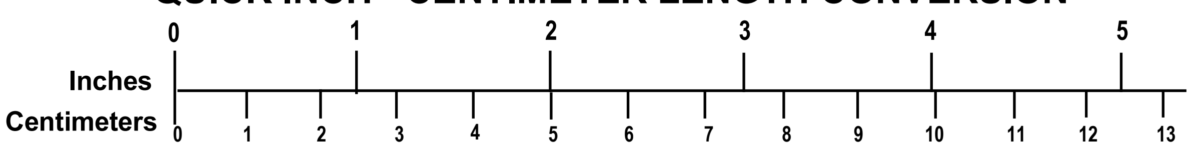
VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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Executive Summary

In the 1970s and early 1980s, the Federal Railroad Administration (FRA) and its contractors conducted extensive research and published several reports that characterized the amplitudes and wavelength content of Track Geometry (TG) throughout the United States. During the subsequent 40 years, railroad operations, track construction, and maintenance practices have changed a great deal, and the general state of repair of the railroad tracks in North America has improved considerably.

FRA contracted Transportation Technology Center, Inc. (TTCI) to characterize the amplitude and wavelength content of the current track geometry environment of the United States railroad system and examine the combination of geometric parameters for different operations. Researchers characterized track geometry data from over 49,000 miles of track, measured between 2012 and 2019. The types of characterization included statistical, frequency-based, and clustering characterization.

The team assessed the waveforms obtained by the clustering analysis, which showed that the irregularity waveforms are complex and cannot accurately be represented by amplitude and wavelength alone. Cusps and inverted cusps approximately 40 feet in length are among the most common irregularity shapes for all analyzed TG variables. 80-foot cusps are seen among alignment irregularities but not among surface irregularities, showing consistency with the frequency-domain characterization results.

The results showed the following findings for United States railroads when considering track geometry:

- Compared to other parameters (e.g., route traffic type, tie type, curvature, etc.), FRA track class has more influence on overall track geometry quality.
- All TG variable values are more severe on track with wooden ties than on track with concrete ties, suggesting that it may be easier to maintain track with concrete ties within a given track class.
- Gage and alignment values tend to be more severe on curved track than on tangent track, likely due to curving forces and rail gage face wear.
- Surface irregularity values tend to be less severe on curved track.
- Cross level and surface values are more severe on freight-only routes than on primarily passenger routes.

The following were found from the various analyses discussed in the report:

- The four principal TG variables (i.e., gage, cross level, mean alignment (average of left and right rail alignment), and mean surface (average of left and right rail surface)) are largely independent.
- Likewise, alignment and surface irregularities within the same rail are not strongly correlated and can be considered as largely independent of each other. However, there is a weak correlation between certain lateral and vertical track irregularities associated with rail length.

- Severe instances where both alignment and surface irregularities exceed the allowable limit are very rare and usually occur with a frequency of 0.02 foot/mile of rail or less.
- Clustering analysis reveals the typical waveform shapes and amplitudes of track irregularities. These waveforms could be further developed for use as representative track inputs to vehicle-track interaction simulation models.

Researchers compared TG data from the 2010s with the data from the 1970s, which showed mixed results. Because the total mileage of data from the 1970s (i.e., 150 miles) is much less than the amount of data from the 2010s (i.e., over 49,000 miles), and the exact locations of the measurements taken in the 1970s are not known, it was not possible to determine from the data whether overall track quality in the 2010s has significantly changed compared with the track quality of the 1970s. However, the following general observations can be made:

- Irregularities associated with 39-foot rails are prominent in the data from both the 1970s and the 2010s. In addition, the gage and alignment data from 2010 also show irregularities consistent with 80-foot rail lengths that were not observed in the 1970s.
- The overall severity of track gage is similar between the old and the new data.
- Mean alignment values seem to be less severe in the new data than in the old data.
- Mean surface and cross level values are inconsistent, with the results varying based on the measuring device and location.

The bivariate statistical tables and clustering analysis discussed in this report facilitate future research in the assessment of track geometry. Below are several examples of how the outputs of this report can be used:

- The single-variable and bivariate statistical tables can be used to estimate the likelihood of encountering simultaneous alignment and surface irregularities of any given magnitude in various FRA track classes.
- The typical irregularity shapes identified by means of clustering present shapes of defect with scalable amplitude that could be used in future track geometry studies to determine the irregularity shapes most detrimental to the vehicle-track system's safety.
- A combination of the bivariate statistical tables and clustering analysis can be used to construct artificial combined track geometries for further study and as vehicle-track interaction simulation model inputs.
- The bivariate analysis methods developed could be useful for planning and prioritizing track maintenance work to target track locations with worst-case irregularity combinations.

The outputs of the analysis included in this report demonstrate some of the capabilities of the computer programs (i.e., MATLAB® scripts) and data analysis algorithms developed throughout this study (the MATLAB scripts and analysis algorithms are available for use in future studies). These software tools and data analysis methods may allow railroad maintenance personnel to perform the following tasks:

- Identification of worst-case combinations of track irregularities

- Evaluation of track irregularity shapes to identify common track features that may generate them
- Prioritization and planning of maintenance work to target worst-case conditions

1. Introduction

The Federal Railroad Administration (FRA) contracted Transportation Technology Center, Inc. (TTCI) to characterize the amplitude and wavelength content of the current track geometry environment of the United States railroad system and examine the combination of geometric parameters for different operations. Researchers characterized track geometry data from over 49,000 miles of track, measured between 2012 and 2019. The types of characterization included statistical, frequency-based, and clustering characterization.

1.1 Background

In the 1970s and early 1980s, FRA and its contractors conducted extensive research and published several reports that characterized the amplitudes and wavelength content of Track Geometry (TG) throughout the United States (Corbin, 1980a; Corbin, 1980b; Hamid, Rasmussen, Baluja, & Yang, 1983b). This data was used to:

- Provide a detailed understanding of the nature of track geometry perturbations, including cross-correlations between different types of perturbations
- Develop the current track safety standards
- Provide input to computer simulation models
- Develop a range of theoretical waveforms used to represent typical TG features, such as rail joints; these waveforms are used to this day in computer simulations of vehicle/track interaction

During the subsequent 40 years, railroad operations, track construction, and maintenance practices have changed a great deal, and the general state of repair of the railroad tracks in North America has improved considerably. Some factors that may have changed include the following:

- More frequent use of Continuous Welded Rail (CWR)
- Longer trains, heavier and longer railcars, improved freight and passenger car suspensions, and changes in operation
- Extensive coal and intermodal Unit Train Service
- Improved track maintenance methods and increased automation of track maintenance

All these changes may impose different wavelengths of perturbations into the tracks.

In addition, TG measurement methods have continuously improved, increasing the accuracy of measurements and expanding the range of measurable wavelengths.

1.2 Objectives

The primary objectives of the study were to characterize the amplitude and wavelength content of the current track geometry environment of the United States railroad system and examine the combination of geometry parameters for different operations.

1.3 Overall Approach and Scope

This study included two tasks. Task 1 consisted of a literature review that concerned the measurement and characterization of TG. The goal of this task was to summarize the current state of TG characterization and to propose a process for characterizing the contemporary TG data. The results of this task are documented in a separate report (Keylin, 2023) and are briefly summarized in Section 2 of this report.

Task 2 consisted of obtaining, processing, and characterizing the contemporary TG data provided by FRA, ENSCO, and Amtrak. This task was performed in close coordination with FRA and the Volpe National Transportation Systems Center. The intermediate results were presented and discussed between the team members. Based on their feedback, the characterization process proposed during Task 1 was refined as follows:

1. The TG data was sorted and pre-screened for artifacts due to special trackwork, sun glare, and other causes. The corrupted data was either repaired or eliminated from the dataset.
2. Additional TG variables, such as mean alignment and mean surface, were derived from the dataset. These variables were used for characterization where appropriate. The emphasis of characterization, however, was on the left and right rail alignment and on the surface data rather than the mean of these measurements.
3. Digital filters were applied where appropriate.
4. The data was sorted by operational conditions: FRA track class, track curvature, predominant traffic type, crosstie type, and geographical region.
5. Manual characterization (i.e., the examination of a subset of TG data by a trained engineer to identify and measure typical irregularities) was attempted but proved impractical and was replaced with a machine-learning method called clustering.
6. Wavelet-based methods of TG characterization were investigated, and it was concluded that these methods were not practical for this study.
7. Finally, the sorted and processed TG data was characterized using several methods:
    a. TG was characterized in the distance domain using statistical methods. The results are presented as single variable tables and bivariate statistical tables.
    b. TG was characterized in the frequency domain using methods based on Fast Fourier Transform (FFT). The results are presented in this report as Power Spectral Density (PSD) and coherence plots.
    c. TG was characterized in the distance domain using k-means++ clustering. The results are presented in this report as clustering plots.

1.4 Organization of the Report

Section 2 summarizes the findings of the literature review conducted during the first task of this study.

Section 3 describes the investigation of wavelet analysis for analyzing track irregularities.

Section 4 describes pre-screening, sorting, and other steps in the processing of TG data which precede the characterization described in the next sections.

Section 5 describes the statistical characterization of TG data in distance domain.

Section 6 describes the characterization of TG data in the frequency domain and compares the current results from those from the 1970–1980s.

Section 7 describes the characterization of TG data using clustering.

Section 8 states the conclusions of this study.

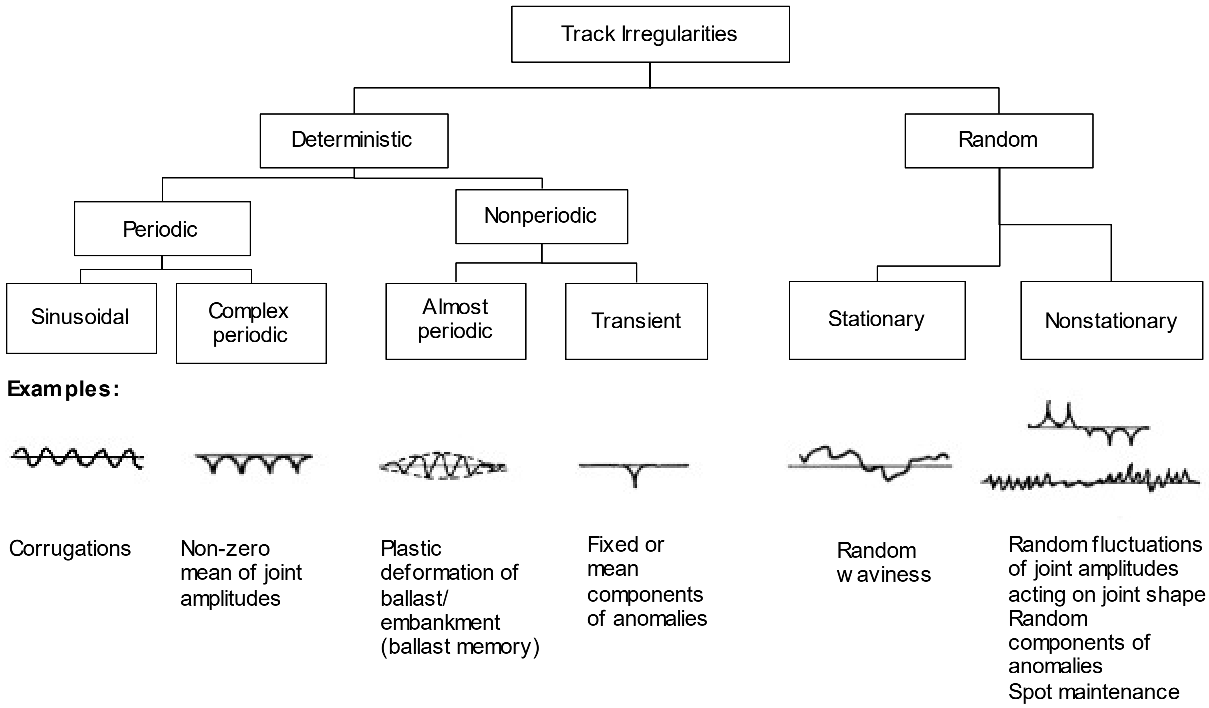
Appendices A–D contain the complete sets of statistical tables, PSD, and clustering plots.

Appendix E discusses the differences between the different track geometry measurement systems and their effects on the results of TG characterization in this study.

2. Summary of Literature Review on Track Irregularities

2.1 Track Irregularity Types

Track irregularities are produced by a variety of physical processes, such as manufacturing defects, rail gage face wear, ballast deformation and settling, and surveying errors. Some irregularities have easily recognizable and repeatable shapes (e.g., cusp shapes often characterize rail joints), yet others are stochastic in nature. All the different irregularity types are superimposed, constituting track geometry (Figure 1).



Adapted from (Corbin, 1980a)

Figure 1. Classification of track irregularities

As a result, mathematical methods suitable for characterizing one type of irregularity may be poorly suited for characterizing other types. This presents one of the biggest challenges of track irregularity characterization.

2.2 Methods of Representation of Track Irregularities

Track geometry cars, such as those used in the FRA Automated Track Inspection Program (ATIP), record track measurements, and irregularities in distance domain (i.e., track curvature, gage, cross level, alignment, and surface) are recorded at equal intervals along the length of the track (i.e., 1-foot intervals in the ATIP car fleet).

There are two main formats of track geometry data recording in distance domain, space curve, and chordal.

In the space curve format, the rail alignment and surface (i.e., profile) variables are defined as deviations of the actual rail positions from their reference trajectories (see Figure 2 and Figure 3). The reference trajectories can be described as smoothed or filtered rail trajectories. This filtering allows the separation of track design elements (i.e., curves and grade) from the track irregularities. The ATIP cars measure the space curve with a linear phase response filter with 400-foot cutoff wavelength.

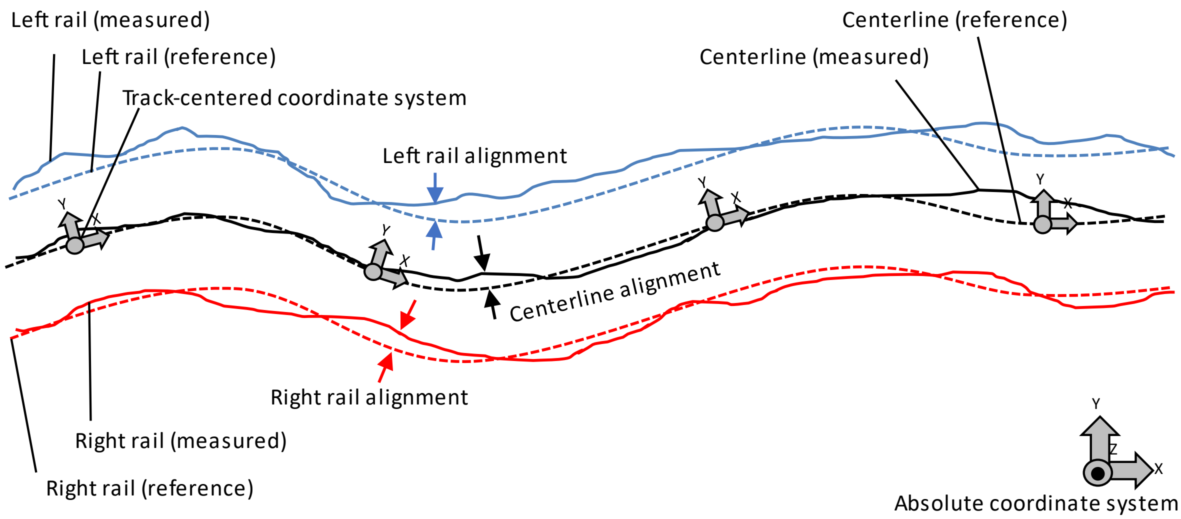


Figure 2. An example of track alignment in the horizontal plane

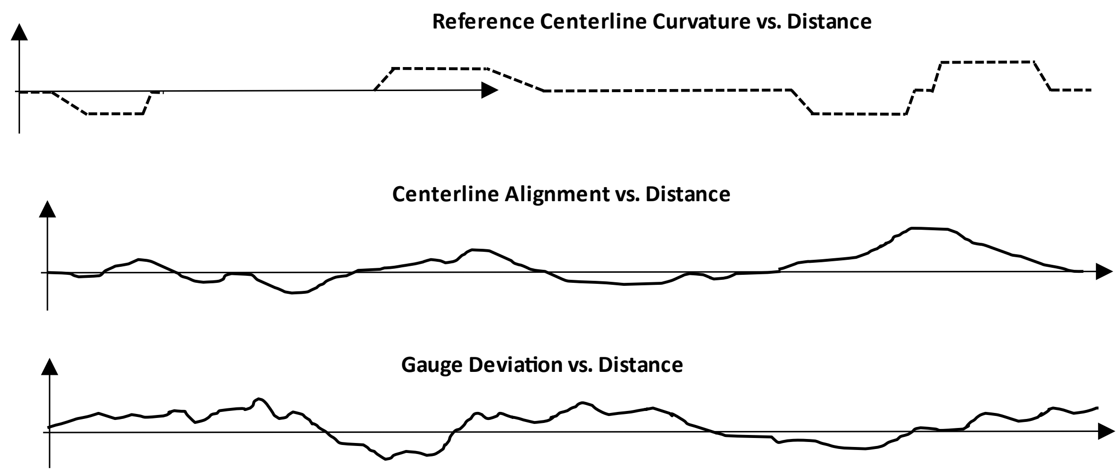


Figure 3. Space curve corresponding to the track in Figure 2

The space curve cannot be measured with simple hand tools. However, this is the format required for accurate vehicle dynamics simulations, and it is the format used in many countries for track safety and quality control (see European standard EN 13848 (European Committee for Standardization (CEN), 2019)).

In the chordal offset (i.e., versine) format, there is no reference trajectory per se (Figure 4). Instead, the rail alignment and surface (i.e., profile) variables are recorded as versines (i.e., distances between the rail trajectory and a chord of pre-defined length). If the versine ratio equals 0.5, these chordal measurements are called mid-chord offset (MCO) measurements. FRA track safety standards are based on MCO measurements with chord lengths of 31, 62, and 124 feet.

Figure 4. Versine (chordal) measurement

MCO measurements are intuitive and easy to make with hand tools, but they distort rail trajectories in that irregularities with certain wavelengths are amplified and other wavelengths are attenuated. Making measurements with multiple chord lengths partially compensates for these distortions (Ahmadian, 1999; Cohen & Hutchens, 1970).

Since lateral mid-chordal offsets in curves are functions of not only track irregularities but also of track curvature, chordal offset measurements also require certain filtering to be compatible with FRA track safety standards, which specify deviation from uniformity filters.

In frequency (i.e., wavelength) domain, track irregularities are presented in terms of amplitude-frequency relationships. In this type of representation, information on individual track irregularities is lost.

2.3 Characterization of Track Irregularities: Process Overview

The process of characterizing track geometry consists of the following (Haigermoser, Luber, Rauh, & Grafe, 2015):

1. Pre-screening the data and eliminating or repairing bad data (e.g., signal spikes, dropouts, etc.).
2. (Optionally) Applying filters to reduce the bandwidth of track irregularities. Low track classes may not benefit from characterizing track irregularities with very long wavelengths, even if a track geometry car could measure these wavelengths.
3. Segmentation of track data into segments (typical length is about 0.1 mile). Ideally, the segments should be homogeneous (i.e., all track within each segment should have the same designated track class, crosstie and fastener type, designation as tangent or curved track, etc.).
4. (Optionally) Calculation of synthetic TG variables (e.g., mean alignment), usually to eliminate redundancies in TG variables. The least redundant set of TG variables consists of curvature, gage, cross level, mean alignment, and mean surface (i.e., profile).
5. (Optionally) Calculation of first and second derivatives of TG variables. Rail vehicle accelerations are more closely related to the second derivatives of the space curve than to the space curve variables themselves. This is well established in computer simulation studies, but the results from the full-scale tests are mixed (Li, Persson, Spannar, & Berg, 2012; Haigermoser, Luber, Rauh, & Grafe, 2015).

6. Application of various characterization methods described in Section 2.4 (e.g., calculating standard deviation of alignment). The methods can be applied to each track segment separately or to the entire measured track.
7. Aggregation of the statistics from multiple track segments (e.g., showing the distribution of cross level standard deviation values among track sections).

2.4 Characterization Methods in Distance Domain

In the distance domain, track irregularities can be processed and characterized mathematically using the following methods:

1. Statistical methods that extract statistical features (e.g., mean, median, percentiles, standard deviation, etc.) of track geometry variables
2. Parametrization methods that describe individual track irregularities using deterministic functions or shape approximations
3. Vehicle response-based methods that attempt to predict vehicle responses to track irregularities

Of the above methods, statistical methods are the most widely used by far. The statistical methods generally fall into one of the following categories:

1. Extraction of statistical features (i.e., minimum, maximum) characterizing isolated track irregularities. This can be used to determine whether a track section meets track safety standards, among other things.
2. Extraction of statistical features that attempt to characterize the overall "roughness" or "quality" of track geometry in each track section (e.g., standard deviation, root-mean-square, etc.) The majority of Track Quality Indices (TQIs) fall into this category, many of them based on the standard deviations of TG variables. However, TG variables, as a rule, are not normally distributed (Krug & Madejski, 2018; Fazio & Corbin, 1982; Corbin, 1980a; Hamid et al., 1983b). Therefore, these statistical features must be interpreted with caution. For example, the frequency of gage defects of certain amplitude cannot be calculated from mean and standard deviation of gage.
3. Methods that are a combination of the first two methods (e.g., track quality indices that calculate number of exceedances of safety thresholds per unit length of track, or percentage of track length that meets a certain track class).
4. Methods attempting to describe the overall distribution of a given track geometry variable, such as probability density functions (PDFs) and cumulative density functions (CDFs). In some cases, a combination of statistical features (e.g., mean, median, skewness, kurtosis, etc.) may be used for the same purpose. These methods provide the most comprehensive representation of each given track geometry, but they are not as concise as other methods (Krug & Madejski, 2018).

A trait most statistical methods share is that they only analyze the frequency of occurrence of different magnitudes of track irregularities and contain no information on the shapes of irregularities. For example, a sine wave with a 40-foot wavelength will have the same mean, median, standard deviation, and PDF and CDF plots as a sine wave with an 80-foot wavelength.

Parametrization methods, on the other hand, may contain information on shapes, but these methods are better suited for characterizing isolated track anomalies (such a dip in a track associated with a rail joint) rather than the entirety of track geometry.

In most cases, statistical methods are applied to either one track geometry variable at a time or to their combination (i.e., the standard deviation of a sum of alignment and profile can be used as a TQI). However, there are statistical methods that describe the relationships between multiple TG variables. For example, correlation matrices or bivariate distribution plots can be used to study the relationships between multiple track geometry variables (Lasisi & Attoh-Okine, 2018).

2.5 Characterization Methods in Frequency (Wavelength) Domain

In the frequency (i.e., wavelength) domain, TG characterization is usually performed on space curve variables to avoid the MCO amplification and attenuation effects described earlier. The most often used frequency domain representation of track geometry is a Power Spectral Density (PSD) function that shows the power densities of different frequency components of a signal. PSD functions are usually calculated using methods based on Fourier transforms that decompose an input signal into a series of sine waves of different frequencies and amplitudes. The application of a simple Fourier transform to a large dataset would produce an output that is very noisy and difficult to interpret. Therefore, various windowing methods are often used. Windowing settings are empirically determined to reach a compromise between preserving the original signal shape and important features while eliminating excessive noise.

The relationships between two TG variables in frequency domain can be shown using coherence functions. The higher the coherence between two variables for a given frequency, the closer the two variables are related at that frequency. Zero coherence implies independent variables. Unlike correlation coefficients, coherence functions can help identify two variables that are only related in a particular frequency range or that are phase-shifted with respect to each other. For example, gage and left rail alignment may have a low correlation coefficient, but their coherence plot will show that their coherence at short wavelengths is very high.

In addition to coherence, the relationship between TG variables can be illustrated with Transfer Functions (TF) and Cross-Power Spectral Density (CPSD) functions. The difference between coherence, TF and CPSD functions is related to the variable with respect to which function is normalized.

Frequency-domain characterization methods are more useful for looking at the “big picture” rather than for describing the quality or safety of smaller track segments. For example, the overall shape of the PSD plot shows the “roughness” of the track in different wavelength ranges, and spikes in the PSD plot show dominate wavelengths, such as a 39-foot wavelength and its submultiples associated with rail lengths. To understand the origin of these submultiples, consider one of the most common types of track irregularity shapes, namely, periodic cusps associated with rail joints.

Figure 5-left shows two periodic functions: a constant-amplitude sine wave (orange) and a variable-amplitude cusp (blue). Both functions have random noise superimposed on them. Figure 5-right shows the PSD of these two functions. The PSD of a sine wave is a single spike at wavelength of 39 feet; the PSD of a cusp wave is a series of spikes at 39 feet and its submultiples (39/2, 39/3, 39/4, …) because a periodic cusp can be approximated by a sum of sine waves with these wavelengths. The variation of the amplitudes of the cusp wave contributes to the overall shape of the PSD curve.

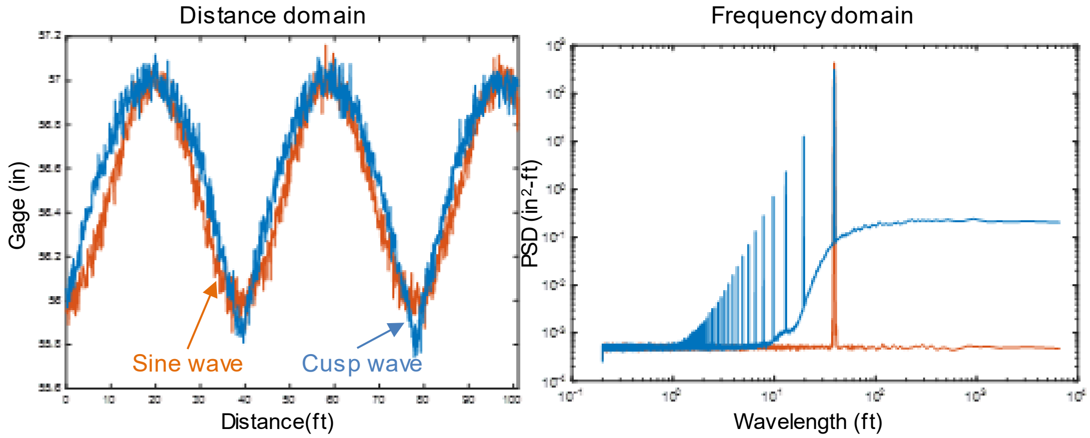


Figure 5. A constant-amplitude sine wave and a variable-amplitude cusp wave (left) and their PSD plots (right)

Frequency-domain methods describe sinusoidal, complex periodic, and stationary random irregularities well, but they contain almost no information on transient irregularities (see Figure 1).

For a concise description of track roughness, PSD curves can be parametrized, for example, by fitted polynomials or piecewise linear functions (Corbin, 1980a). Such parametrizations usually do not include spikes associated with periodic irregularities related to rail length.

2.6 Manual Characterization

In this context, manual characterization means the examination of space curves or MCO data without an extensive use of computer algorithms. Instead, a specialist inspects the TG plots, visually identifies isolated track irregularities (e.g., rail joints or anomalies), and records the lengths and amplitudes of the track irregularities. The data from multiple irregularities can be aggregated (i.e., distribution of amplitudes of vertical irregularities associated with rail joints).

The advantage of this method is that a trained eye can reliably identify certain patterns, even though it would be difficult to create a computer algorithm that could identify the same pattern. This approach, among other methods, was used in the 1970s–80s FRA-sponsored study to identify common track anomalies and estimate their dimensions (including, in some cases, a distribution of their amplitudes) (Corbin, 1980a; Hamid et al., 1983b; Corbin, 1980b).

The largest limitation of manual characterization is that it is time and labor intensive and, realistically, can only be used on small datasets. Other limitations are less obvious: manual characterization is subjective, and the results will depend on the researcher's skill level and interpretation of different waveforms; additionally, irregularity shapes may be difficult to detect when their small amplitudes are masked by the random waviness of the track. For example, the characteristic cusp-shaped irregularities near rail joints may be easy to identify in a Class 2 track but not in a Class 5 track.

In this study, an attempt at the manual characterization of track geometry was made, but the attempt had to be abandoned due to the above-mentioned random waviness effects.

3. Use of Wavelet Analysis in Track Geometry Characterization

3.1 Background

Wavelets are short-duration waveform functions that include certain properties, such as having zero mean. These functions can be used to decompose a signal at smaller-scale and larger-scale components, a process called wavelet transform. The wavelet transform shares certain properties and applications with the Short-Time Fourier transform (STFT). However, unlike the Fourier transform, the wavelet transform does not rely on signal periodicity and can precisely localize certain signal components in time. Furthermore, the wavelet transform is well-suited for the analysis of signals with sharp discontinuities. In terms of track geometry, these properties mean that wavelet analysis may be well-suited for locating certain track irregularities, such as cusp shapes associated with rail joints. Any transient track irregularity signal can be used to create a wavelet if it satisfies the zero-mean condition (Haigermoser et al., 2013). The plot of the time-frequency information obtained from a wavelet transform is referred to as a scalogram.

The one drawback of the STFT is that the frequency resolution reduces as the time window narrows. A short-time window allows good time localizations and poor frequency resolutions and the opposite for longer time windows. The wavelet transform attempts to improve on this drawback. With the wavelet transform, the higher frequencies have good time or distance localization, though the frequency resolution is poor. With lower frequencies, the frequency resolution is improved, but the time or distance localization is poor. Measured signals often have higher frequency components that need to be localized more accurately in time or distance, whereas the lower frequency components are present over longer times or distances and thus do not require accurate localization in time or distance. This makes the use of the wavelet transform attractive for measured signals.

The wavelet transform makes use of a "mother wavelet" of fixed amplitude and period. The period of the wavelet is scaled (i.e., increased or decreased), and each scaled wavelet is time or distance shifted and compared to the measured signal. The wavelet transform determines where there is good agreement between the scaled wavelet and the measured signal and provides time and scale information. When this agreement is good, the amplitude of the wavelet transform is large. The scale is a measure of the period and therefore is related to the frequency of the signal. The wavelet transform thus provides time-frequency (i.e., distance-frequency) information.

The wavelet transform is widely used in signal processing. It is not only used for time-frequency analysis, but, due to its mathematical formulation, it also finds application in denoising and/or compression of data and images. Wavelet denoising is an attractive feature of the wavelet transform. Denoising with wavelets does not smooth the signal by removing only high frequencies but rather attempts to remove the noise from all frequencies. Applications of the wavelet transform, as well as examples of wavelet denoising, are described by Dautov and Ozerdem (2018).

The choice of the mother wavelet is an important consideration. Figure 6 compares various wavelet shapes. It is expected that many measured signals would have similar shapes to the Morlet, Mexican Hat, and Gaussian wavelets, since these wavelets have sinusoidal forms. The Haar wavelet is used to analyze the local aspects of a signal and is especially useful for edge detection. The type of application determines the most appropriate wavelet.

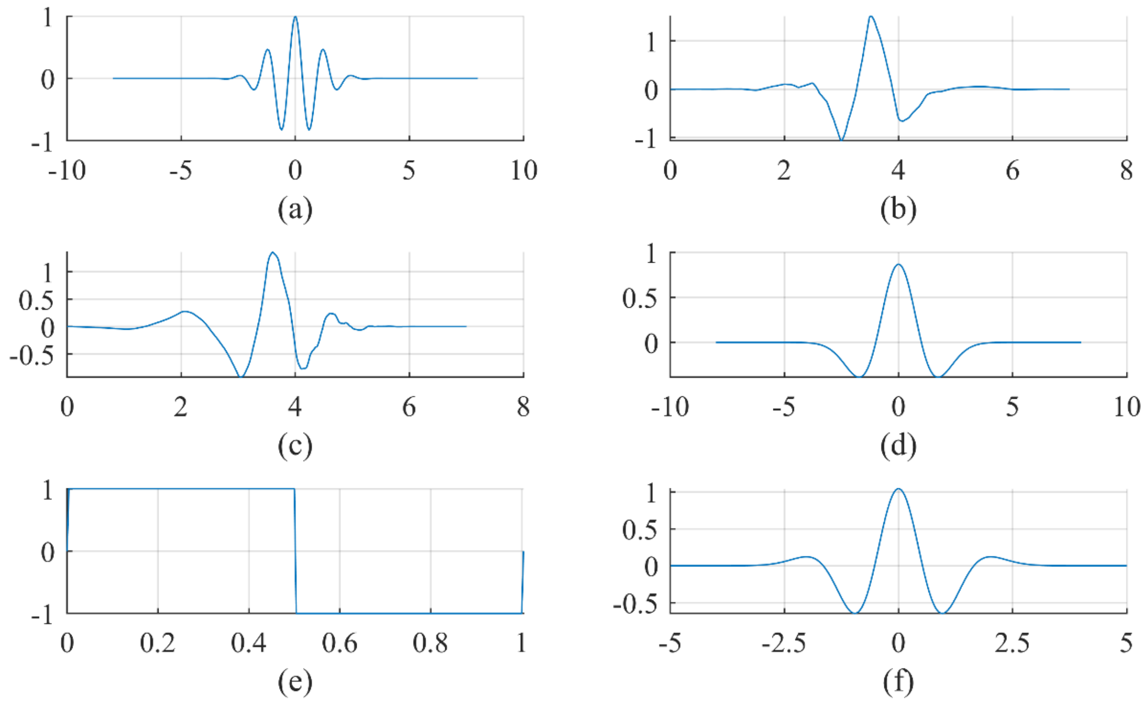


Figure 6. Comparison of (a) Morlet, (b) Symlets, (c) Daubechies, (d) Mexican Hat, (e) Haar, and (f) Gaussian wavelets

3.2 Application of Wavelet-Based Methods for Track Geometry Characterization: Literature Search Results

A literature survey was used to identify studies that used wavelet-based methods to characterize track irregularities. A more in-depth literature survey was then conducted to identify more publications on this topic. Several track geometry experts in the US and abroad were consulted to obtain more information about their work involving wavelet-based methods (Keylin, 2023).

The results of this literature search were as follows:

1. Schoeler, Corves, Scholle, and Moser (2017) used the following workflow to detect transient track irregularities using wavelets. First, the second order derivative of the signal is calculated. Then, a Continuous Wavelet Transform (CWT) is performed using Mexican Hat and Gauss 3 wavelets to locate the transients matching either of those wavelets. The results of this algorithm are then used to synthesize artificial transient track irregularities that could not be synthesized from a PSD.
2. Zeng, Liang, and Zhang (2010) used a combination of wavelet decomposition (i.e., Daubechies db10 wavelet) and a PSD estimate to determine the locations and wavelengths of various types of track irregularities. The focus was to identify the locations, wavelengths, and amplitudes of specific irregularities.

3. The European DynoTRAIN project (2009–2013) parametrized track defects using the Mexican Hat wavelet, the shape of which resembles a typical track defect. The study parametrized the measured track irregularities using wavelets; it then correlated the maximum correlation coefficient of the wavelet energy with forces and accelerations measured by the vehicle negotiating the track. The results brought no substantial improvements compared to standard deviation-based characterization methods (Haigermoser et al., 2013).
4. Kraft, Causse, and Coudert (2015; 2018) used the wavelet-based approach in two different ways:
    - By performing a CWT of the entire track geometry dataset using standard wavelet shapes. However, the authors note in personal communication that this approach did little for the classification of the track geometry defect shapes.
    - A Clustering approach in which wavelet transform is used to calculate similarity between two defects (as an alternative to calculation of Euclidean distance between two defects). In this approach, a wavelet is defined for each track defect, and then the wavelet is applied to the other defect. This approach was more successful than the first; nevertheless, many defects could not clearly be attributed to a particular defect class. Therefore, this approach was abandoned by the authors in favor of feature-based clustering classification.
5. The Center for Vehicle Systems and Safety at Virginia Polytechnic Institute and State University used a wavelet-based method for the characterization of track defects; however, the method used vehicle accelerations rather than track geometry variables like alignment and cross level (Hopkins, 2012).
6. The European Rail Research Institute (ERRI) study in the 1990s proposed the use of wavelets, specifically Haar wavelets (UIC, 1999), to compile a catalog of track defect types.
7. Lee, Kim, and Yeo (2006) used wavelet transform with a Morlet wavelet to analyze changes in track geometry over time on a short-track segment. Little information on this study is available in English, but it appears that the method used in the study is not applicable to identifying common track irregularity shapes.

3.3 Use of Wavelet Transform for Localization of Cusp-Shaped Track Irregularities

The continuous wavelet transform was used to compute the distance-frequency content measured track geometry. The measured track geometry was recorded on Transportation Technology Center's (TTC) Wheel/Rail Mechanism (WRM) loop. A custom wavelet was generated to represent the analytical definition of a cusp shape.

This shape is typical of vertical perturbations associated with rail joints. This generated Cusp wavelet is shown in Figure 7. The distance-frequency values were calculated using the Morlet wavelet or the Cusp wavelet as the mother wavelet.

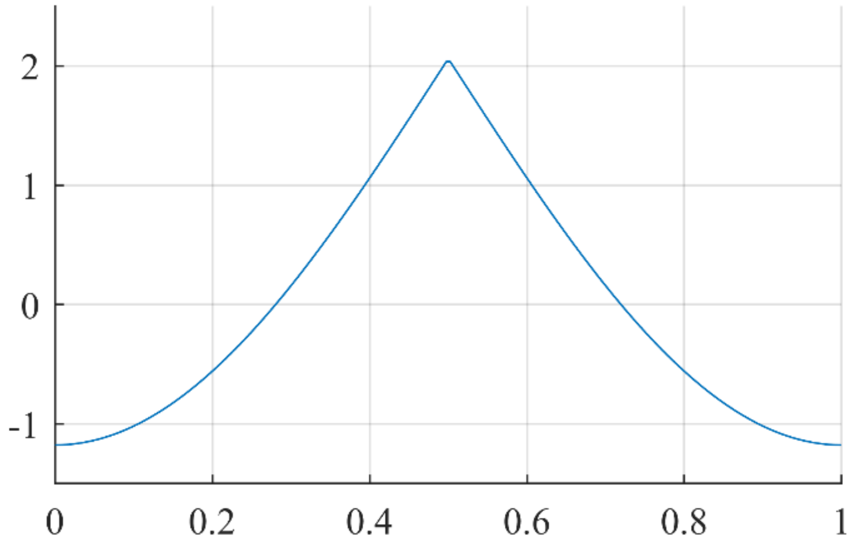


Figure 7. The custom generated Cusp wavelet

The left rail's profile (i.e., surface) geometry was analyzed with a Morlet wavelet, and the resulting scalogram is shown in Figure 8. The measured track geometry between 5,500 and 7,000 feet is dominated by a sinusoidal shape with a wavelength of about 40 feet. The location of each individual measured waveform is not discretely localized, but the general location of this high-amplitude sinusoidal shape is identifiable.

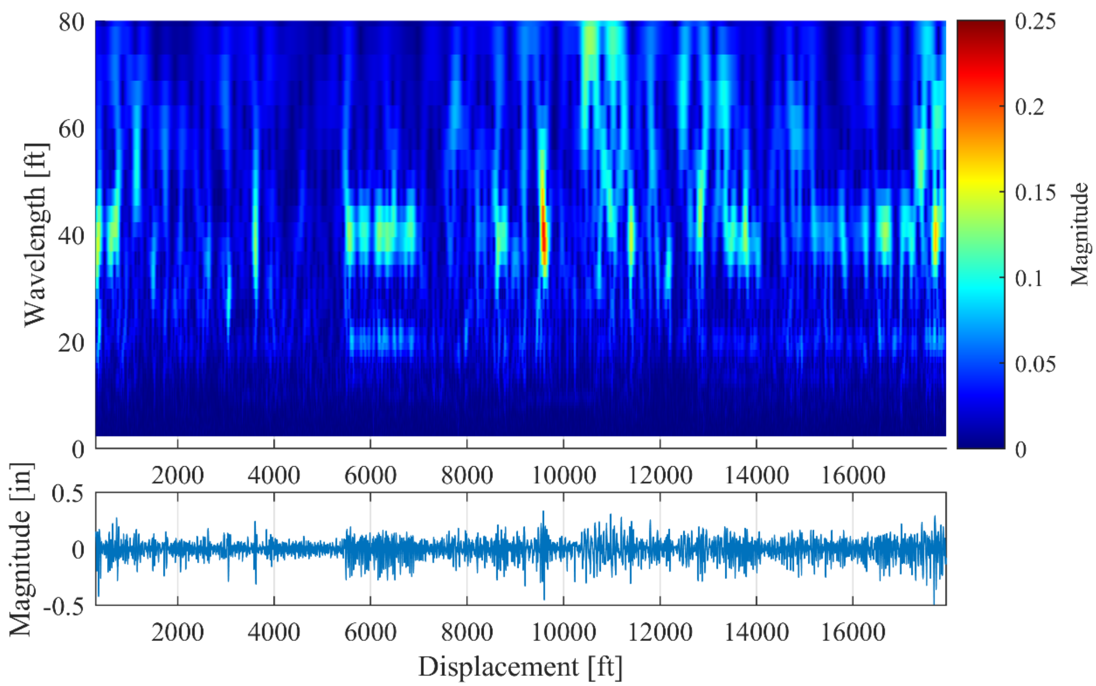


Figure 8. Scalogram of the left profile geometry calculated with the Morlet wavelet

The custom-generated Cusp wavelet was generated to localize the start and end of cusp shapes more discretely. The scalogram that was produced from the analysis of the left profile geometry with the Cusp wavelet is shown in Figure 9. There appeared to be more discrete instances of high amplitudes corresponding to potential cusp shapes although the wavelengths are not near 40 feet but appear to be some other related value. Figure 10 shows a zoomed version of this scalogram, and it is shown that high amplitudes of the scalogram coincide with the cusp shape near 9,600 feet. There are high amplitudes identified at either end of the cusp that could be misleading. Nevertheless, this method appears to be able to localize cusp shapes in measured data.

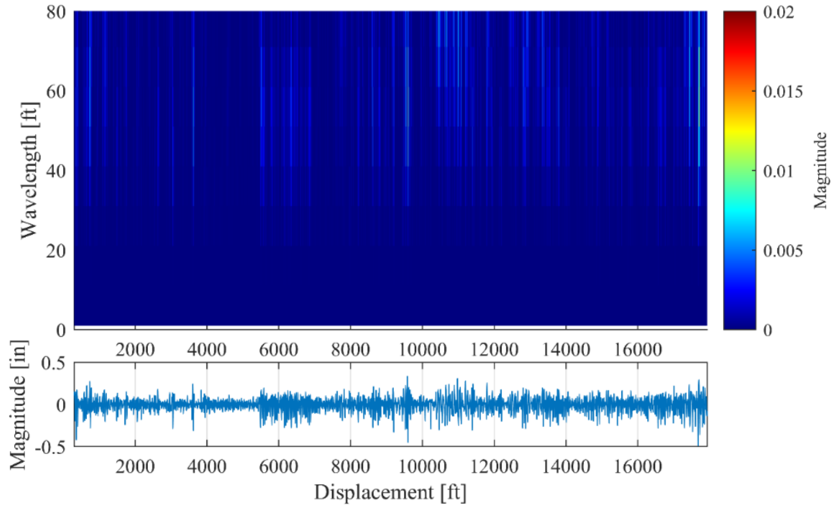


Figure 9. Scalogram of the left profile geometry calculated with the Cusp wavelet

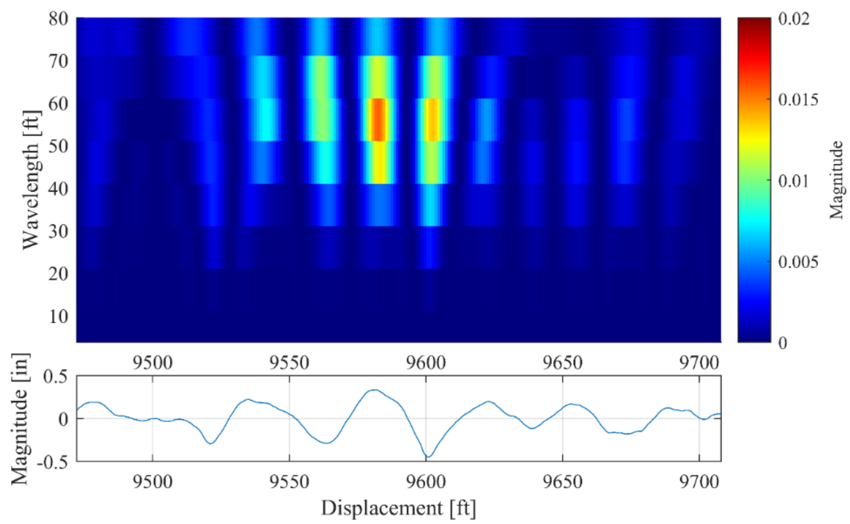


Figure 10. Scalogram of the left profile geometry calculated with the Cusp wavelet zoomed to illustrate cusp identification

3.4 Use of Wavelet Transform for Denoising of Track Geometry

As described earlier, track irregularities result from several different process types.

Denoising track geometry can be used to remove the measurement noise (the result of a stationary random process) inherent in the track geometry measurement. This denoising would further facilitate the decomposition of the measured track geometry into deterministic shapes such as cusps or bumps. Denoising could also further facilitate the characterization of the measured geometry as the number of these shapes, their wavelengths, and their amplitudes.

The measurement noise may not be found only in the high frequencies of the measured signal. For example, if the noise is assumed to be pure white noise, the noise may be distributed across all frequencies. Various methods are available to denoise a signal. Two methods that are based on the Fourier transform were implemented, as well as a wavelet denoising method:

- The first Fourier-based method calculated the spectrogram or distance-frequency information of a signal. This method then eliminates all frequency components with amplitudes below a given threshold. This operation is performed in the frequency domain. The remaining frequency content is then inverted to the distance domain using inverse Fourier transform. This method is referred to as the Mask.
- The second Fourier-based method is the Block-Thresholding method, and the denoising procedure is described by Yu et al. (2008). This method groups distance-frequency information into blocks and applies a single attenuation value over these distance-frequency blocks before transforming back to the time domain.
- The wavelet denoising method was applied with the MATLAB® Wavelet Toolbox. There are various wavelets and accompanying settings that can be applied to denoise a signal, and the resultant denoised signal will depend on the choice of wavelet and accompanying setting.

An analysis was performed using analytical track geometry generated with the analytical description of a cusp with randomly generated cusp amplitudes. Noise was artificially added to the generated track geometry to determine the success of the denoising method. An ideal denoising method would preserve the cusp shape (including random amplitudes) while removing the high-frequency noise.

The denoised signals from the three methods are compared against one another in Figure 11.

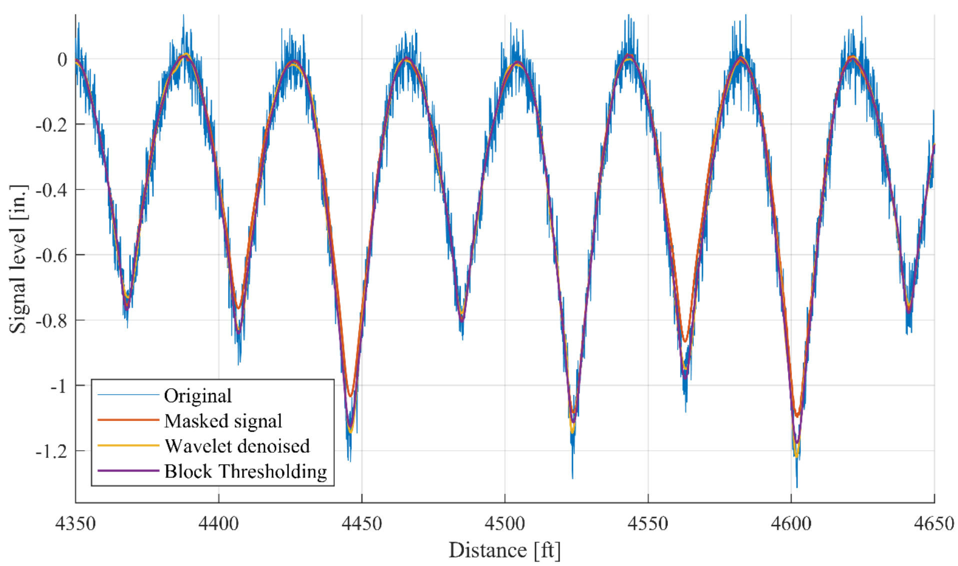


Figure 11. Comparison of denoising methods for analytically-generated track geometry

The wavelet-based method seemed to estimate the peak amplitude at the troughs well. The denoised signals of the wavelet and the Block-Thresholding methods compared well with one another. The smoothing of the Block-Threshold methods can be seen at the crest before 4,400 feet where the wavelet-based method produced a more uneven denoised signal.

Overall, the three denoising methods, especially wavelet-based denoising, performed quite well when denoising this artificially generated track irregularity signal.

Next, the three methods were applied to the measured track geometry from the WRM loop. The frequency content present in the denoised signal and the frequency content in the remaining noise are compared in Figure 12 for the three methods. The signal was denoised with the Symlets no. 16 wavelet. The spatial frequency content below a wave number of 0.175 foot^{-1} for the three different methods appears to be similar in Figure 12(a). The Fourier-based methods appear to roll off at a faster rate than the wavelet-based method. The frequency contents that remained after the denoising methods were applied are shown in Figure 12(b). The Fourier-based methods appeared to eliminate frequency content between a 0 and 0.1 foot^{-1}. This frequency content could potentially still be a valuable part of the signal. The remaining noise from the wavelet denoising appears to have more constant amplitude across the spatial frequency range.

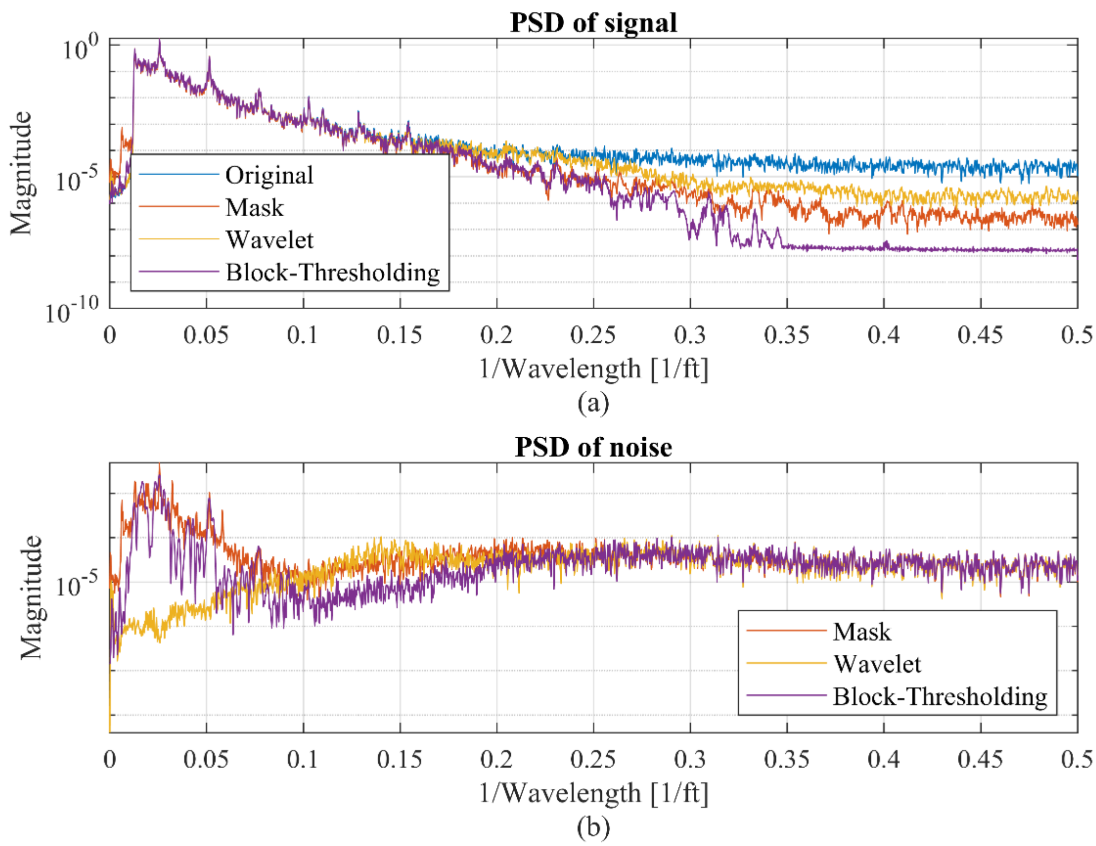


Figure 12. Comparison of the frequency content present in (a) the denoised signals and (b) the noise component of the signal

The reconstructed distance-based signals are compared in Figure 13. All three methods remove noise to some degree. The Fourier-based methods appear to smooth the data more than the wavelet-based method. The wavelet-based method maintains more of the sharp transitions and peak values. This comparison shows that wavelets offer a method to denoise track geometry, though the accurate representation of the true signal by the denoised signal is uncertain.

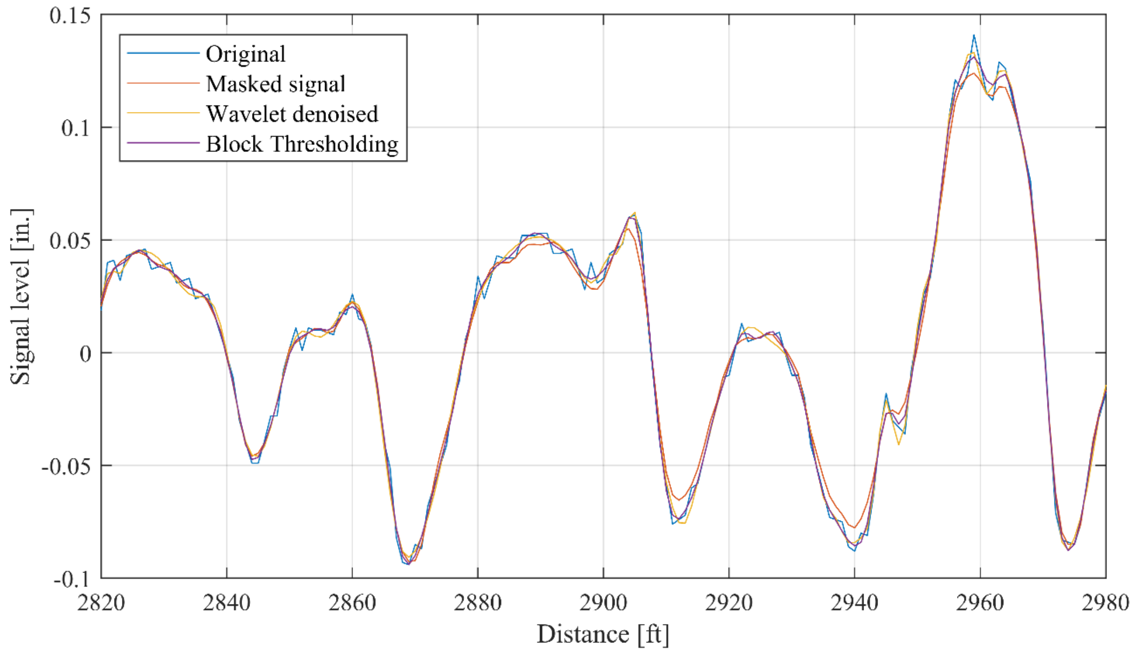


Figure 13. Reconstructed distance-based signals from denoising process

The results of denoising the measured TG signal showed that the methods that performed well on an artificial signal appeared to be less useful for real measured track geometry. The reason behind this is that the "signal" versus "noise" separation boundary in real TG is very blurry, with a stationary random process, a periodically modulated deterministic process, and anomalies interacting in complex ways. The denoising methods that were tried attributed almost all the irregularities to "signal" and very little to "noise," making the method, at least with the settings used so far, of little practical use for separating stochastic and quasi-deterministic irregularities.

4. Processing of Track Geometry Data

4.1 Overview of Collected Track Geometry Data

The combined data set provided by FRA, ENSCO, and Amtrak consisted of 736 files recorded between January 2012 and January 2019. The total mileage was 55,117.

Although an effort was made to minimize data duplication, some sections of track in the database were measured more than once at different dates. The length of duplicated data was not determined.

Twenty-five percent of files with the lowest validity ratio (i.e., the amount of irreparable data per mile; see Section 4.3 for a detailed description of validation and repairs) were discarded. An additional 25 percent of files with the highest fraction of repairable signal spikes were also discarded. Because of the overlap between these two groups, a total of 34 percent of files were excluded from characterization.

The remaining data set consisted of 489 files with a total of 49,739 miles of track (Table 1).

Table 1. Track mileage in the database after discarding files with low validity ratio

Traffic Type	FRA Track Class								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOTAL**
Freight Only	541	2,173	5,280	12,410	2,609	2	0	0	**23,015**
Primarily Freight	205	990	3,818	14,522	4,778	5	0	0	**24,319**
Primarily Passenger	12	98	660	801	277	145	228	185	**2,405**
TOTAL	**759**	**3,268**	**9,758**	**27,733**	**7,664**	**152**	**228**	**185**	**49,739**

Figure 14 and Figure 15 illustrate the variety of FRA track classes and traffic type on the analyzed segments.

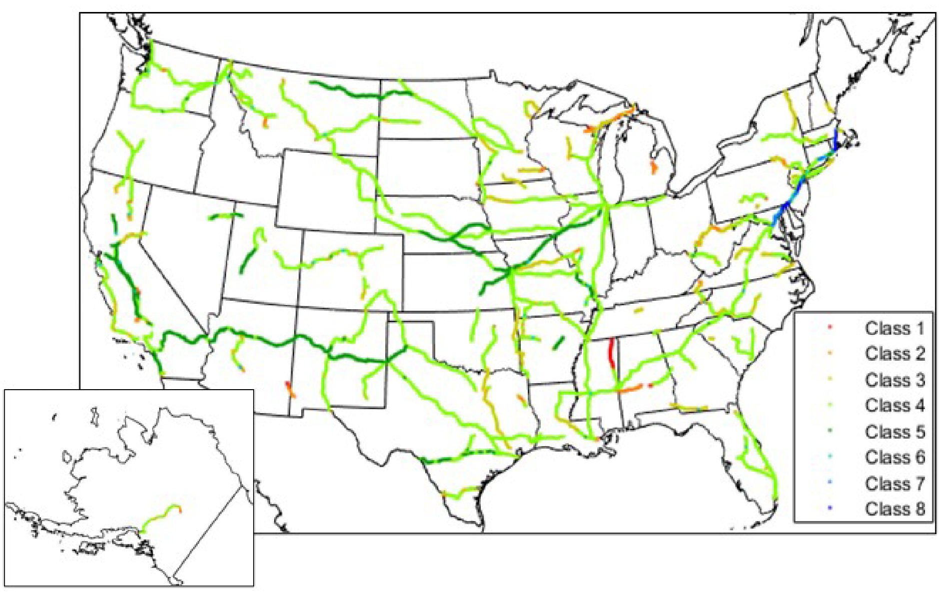


Figure 14. Analyzed track geometry sorted by FRA track class

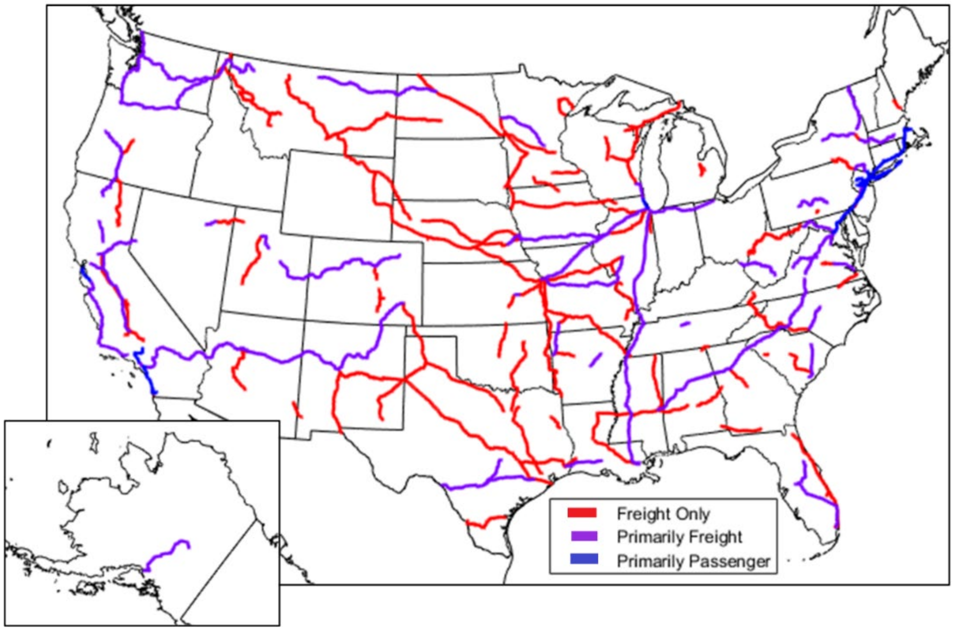


Figure 15. Analyzed track geometry sorted by traffic type

4.2 Overview of Workflow

The track geometry was processed using a series of MATLAB scripts that used the built-in functions, several third-party function libraries (Greene et al., 2019; Wasmeier, 2018), and custom subroutines written for this task. The significant volume of raw TG data (i.e., over 70 GB) made it necessary to use special functions designed for large files.

The workflow is described below.

1. Comma-separated ASCII files containing raw TG data were converted into a binary format to facilitate the next steps. Each file was associated with a certain traffic type (i.e., freight only, primarily freight, or primarily passenger) based on the information from ENSCO.
2. Each TG file was divided into segments up to 0.1 miles long. For each segment, FRA track class, posted speed, track curvature (i.e., tangent/curved), tie type (i.e., wood/concrete/unknown), and geographical region (i.e., West/Midwest/Northeast/South) were recorded.
3. Auxiliary TG variables were calculated, including mean alignment (i.e., the average of left and right rail alignment), mean profile[1], and gage and cross level rates of change.
4. TG data was validated, and artifacts were identified (see Section 4.3). Small artifacts were repaired by interpolation; areas with large artifacts or with failed cross-checks were marked as invalid. TG files with large amounts of invalid data were discarded from further analysis.

[1] In this report, the terms "centerline alignment" and "mean alignment" are used interchangeably. The same applies to "centerline profile" and "mean profile."

5. Alignment and profile space curve data was filtered with high-pass second order Butterworth filters with a cutoff wavelength of 200 feet. The filters were cascaded in forward and in reverse (using the *filtfilt* function in MATLAB) to eliminate phase distortion[2]. Unfiltered space curve data was used for characterization in frequency domain, and filtered space curve data was used for statistical and clustering characterization.
6. The validated data was divided into eight separate binary files, with each file corresponding to one FRA track class.
7. Selected TG variables from the eight binary files were retrieved from memory and processed by TG characterization functions, producing the outputs shown in this report (e.g., statistical tables, PSD plots, etc.)

4.3 Validation

Stringent validation rules were established to eliminate invalid TG data from characterization.

Most inertial track geometry measurement systems (TGMS) require the track geometry car to move at a certain minimum speed to produce valid results; for ATIP cars, profile (i.e., surface) MCO data requires a minimum speed of 5 mph, alignment MCO requires a speed of 15 mph, and the space curve requires a speed of 30 mph (Bruzek, 2018). Since the validation rules used in this study relied on the space curve to perform cross-checks, all TG data below 30 mph, except gage and cross level, were considered invalid. This means that for FRA Class 1 and the majority of FRA Class 2 track only gage and cross level were analyzed.

TG data often contains signal artifacts in areas of turnouts, crossings, and other special trackwork where TGMS may have difficulty locating the gage point and the top of rail. Signal artifacts may also be caused by sun glare, snow, sleet, or debris. Such artifacts were identified and corrected or removed from the analyzed dataset before the TG characterization was performed.

The validation algorithm used for this study identified three types of signal artifacts: spikes, dropouts, and range exceedances.

Spikes were detected as follows:

1. A change of gage or cross level greater than 0.25 inch over one foot was considered the start of a spike.
2. The end of a spike was reached once at least 25 valid gage/cross level data points in a row were observed. For a datapoint to be considered valid, rate of change of gage/cross level must not have exceeded 0.25 inch per foot, and the gage/cross level value must have been realistic (i.e., gage between 55.5 to 59.0 inches, cross level between -10 and 10 inches).
3. If a gage or cross level spike was less than 35 feet long, then all relevant TG channels (i.e., gage and alignment for gage spikes, cross level and profile for cross level spikes) within that area were repaired by linear interpolation. In MCO channels, the areas 1/2

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[2] Note that cascade (i.e., multi-pass) application of filters increases the effective filter roll off rate and shifts its cutoff frequency. Correction factors for Butterworth filters exist (Selling, 2018) and they have been applied to clustering analysis but not to statistical characterization.

chord length ahead and behind the spikes were also repaired. After the repair, the data near the spike was considered valid.

4. If a gage or cross level spike was 35 feet or longer, it was considered non-repairable. All TG data within the spike and within 100 feet from it were marked as invalid.

Signal dropouts were detected as follows:

1. Datapoints where gage was tighter than 55.5 inches or wider than 59.0 inches, or cross level was less than -10 inches or over 10 inches, were considered dropouts. All TG data in these locations were marked as invalid.
2. Areas where gage or cross level stayed constant for 20 or more consecutive datapoints were considered dropouts. All TG data in these locations were marked as invalid.

Range exceedances were detected whenever the left or right alignment space curve value was below -10 inches or over 10 inches. The space curve data at these points was considered invalid, but other data (i.e., gage, cross level, MCO) was considered valid.

In addition to detecting artifacts, cross-checks of TG data were performed. Gage cross-check was performed by calculating "synthetic gage" (i.e., the difference between left and right alignment space curve) and comparing it with the raw gage filtered with a high-pass filter. Cross level cross-check was performed similarly using cross level and vertical space curve variables. If the gage discrepancy exceeded 0.125 inch or the cross level discrepancy exceeded 0.25 inch, the data within 2,000 feet of that discrepancy was considered invalid.

Furthermore, if a track segment had any datapoints with invalid gage or cross level, then all TG data from that entire 0.1 mile segment was considered invalid. Similarly, if a track segment had any areas with an invalid space curve or invalid MCO data, that entire segment was considered invalid for the space curve or MCO analysis.

5. Statistical Characterization Results

5.1 Analysis of Individual TG Variables

The tables in Appendix A show the following statistics for select TG variables: percentiles (0.001th, 1st, 25th, 50th, 75th, 99th, and 99.999th), mean, mode, standard deviation, interquartile range (IQR), skewness, and kurtosis. Each table breaks the results down by track class and optionally by one of the following categories: track curvature (i.e., tangent vs. curved track), geographical region, crosstie type, or traffic type on the route (i.e., freight only, primarily freight, and primarily passenger). The "usable mileage" field shows the track mileage from the category that was used for statistical analysis after validation (Section 4.3). If the usable mileage in the category was less than 10 miles, the statistics for the category are not listed.

Note that for Class 2 track, only 28 miles of track were suitable for alignment and surface analysis. ATIP TGMS systems require an operating speed of 30 mph or higher to measure the space curve while the operating passenger speed limit for FRA Class 2 track is 30 mph (49 CFR 213.9). It is possible that these 28 miles of track were incorrectly attributed to Class 2. Therefore, the statistics for alignment and surface irregularities in Class 2 track should be used with caution.

The sign convention used in these tables is below:

- Cross level: left rail elevated is positive (in the direction of travel as measured by the TGMS)
- Alignment: deviation to the left is positive (for either left or right rail)
- Surface: upward deviation (bump) is positive

Table 2 is an example of such a table.

Table 2. Gage statistics by FRA track class and track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	430.5	55.623	56.003	56.343	56.481	56.619	57.028	57.862	56.484	56.492	0.215	0.276	0.211	3.536
	Curved	295.2	55.615	56.072	56.449	56.618	56.835	57.544	58.255	56.663	56.532	0.310	0.386	0.711	3.669
2	Tang.	1,837.0	55.762	56.099	56.398	56.508	56.626	56.988	57.628	56.515	56.492	0.181	0.228	0.264	3.687
	Curved	1,403.5	55.745	56.209	56.512	56.662	56.858	57.382	57.937	56.698	56.532	0.257	0.346	0.570	3.211
3	Tang.	5,747.9	55.859	56.166	56.422	56.524	56.634	56.969	57.504	56.532	56.492	0.166	0.212	0.328	3.633
	Curved	3,983.4	55.831	56.252	56.532	56.673	56.839	57.315	57.858	56.698	56.571	0.230	0.307	0.530	3.286
4	Tang.	20,961.2	55.886	56.201	56.433	56.532	56.642	56.969	57.413	56.543	56.492	0.161	0.209	0.372	3.437
	Curved	6,731.0	55.923	56.256	56.508	56.634	56.775	57.158	57.658	56.649	56.571	0.196	0.266	0.407	3.122
5	Tang.	6,345.5	55.930	56.213	56.398	56.477	56.571	56.878	57.272	56.491	56.453	0.138	0.173	0.558	3.740
	Curved	1,309.7	55.894	56.260	56.485	56.595	56.713	57.044	57.441	56.605	56.571	0.170	0.228	0.369	3.136
6	Tang.	93.3	55.946	56.316	56.499	56.565	56.658	56.859	57.203	56.579	56.532	0.116	0.159	0.233	3.324
	Curved	58.9	56.018	56.371	56.519	56.585	56.672	56.955	57.546	56.604	56.555	0.124	0.154	0.739	3.897
7	Tang.	150.2	55.930	56.356	56.518	56.590	56.676	56.847	57.351	56.597	56.536	0.111	0.158	0.130	3.083
	Curved	77.8	56.113	56.413	56.554	56.639	56.741	56.979	57.221	56.654	56.566	0.130	0.187	0.426	2.777
8	Tang.	157.9	55.975	56.370	56.514	56.580	56.634	56.798	57.215	56.577	56.593	0.091	0.120	0.053	3.502
	Curved	27.4	56.323	56.438	56.596	56.655	56.743	57.009	57.204	56.677	56.635	0.120	0.147	0.710	3.563

The following conclusions can be drawn from these statistics:

- **FRA track class:** For all analyzed TG variables, FRA track class is the most important predictor of TG roughness, as evident from the measures of spread (i.e., standard deviations and IQR). For example, standard deviation of gage on Class 8 track is over 60 percent lower than on Class 1 track.
- **Track curvature:** Gage and alignment tend to be less uniform on curved track than on tangent track, but cross level and surface tend to be more uniform on curved track. In addition, the average gage is wider on curved track than on tangent track.
- **Crosstie type:** Gage, cross level, alignment, and surface are less uniform on track with wooden ties than on track with concrete ties.
- **Traffic type (freight only versus primarily freight versus primarily passenger):** Cross level and mean surface are less uniform on freight-only routes than on primarily passenger routes. There is no consistent pattern for gage and alignment uniformity versus traffic type.
- **Geographical region:** While there is some variability in TG statistics between different geographical regions, the patterns are not consistent. For example, the Class 2 track cross level is less uniform in the Midwest than in the South, but the opposite is true on Class 3 track.

5.2 Bivariate Distributions

Bivariate distribution tables are frequency tables that show the distribution of two variables. The data in such a table can also be expressed in a three-dimensional histogram.

Appendix B contains the complete set of bivariate distribution tables from this study. These tables can be used by track owners, operators, and regulatory agencies to estimate the likelihood of simultaneous alignment and surface irregularities of any given magnitude in each FRA track class. The tables do not describe the shapes or wavelengths of those irregularities; this information can be found in PSD plots (Section 6) or clustering plots (Section 7). The bivariate tables in this report are provided for MCO variables rather than for space curve variables because MCO are the values specified in the track safety standards (49 CFR 213.55, 213.327, 213.63, 213.331).

Table 3 is an example of a bivariate distribution of alignment and surface deviations (62-foot MCO, FRA Class 8 track). The number in each cell represents the footage per mile of rail where the given alignment and surface MCO values are exceeded simultaneously. For example, one mile of rail length has an average of 2.15 feet where the rail deviates by more than 1/8 inch to the outside and simultaneously more than 1/4 inch upward. The MCO values permitted for the given FRA track class are highlighted in green. The alignment MCO values permitted for tangent track, but not for curved track, are highlighted in yellow (see 49 CFR 213.55, 213.63(a), 213.327(b), and 213.331(a)).

Table 3. Distribution of 62-foot MCO alignment and surface values on Class 8 track

CLASS 8		Inward alignment deviation exceeding:									Outward alignment deviation exceeding:									TOTAL
62ft MCO		-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	
Upward surface deviation exceeding:	2																			
	1 3/4																			
	1 1/2																			
	1 1/4																			
	1																			
	7/8																			
	3/4								0.00	0.00										0.00
	5/8							0.02	0.08	0.15	0.10	0.02								0.25
	1/2						0.01	0.12	0.29	0.92	0.57	0.12								1.49
	3/8						0.04	0.33	1.15	4.73	3.08	0.51	0.04							7.81
	1/4					0.00	0.11	0.81	4.57	23.70	15.66	2.15	0.22	0.03	0.01					39.36
	1/8					0.03	0.33	1.95	15.54	141.73	110.68	9.25	0.81	0.07	0.01					252.41
	0					0.09	0.74	4.28	49.24	1412.21	1300.21	40.14	2.73	0.26	0.05					2712.42
Downward surface deviation exceeding:	0			0.01	0.05	0.15	0.53	3.73	40.40	1217.13	1350.45	54.36	5.03	0.64	0.05					2567.58
	- 1/8			0.00	0.02	0.05	0.24	1.68	11.96	109.32	148.05	19.92	2.85	0.40	0.02					257.36
	- 1/4						0.05	0.59	4.04	21.92	35.65	8.97	1.73	0.27	0.02					57.57
	- 3/8						0.00	0.22	1.40	6.76	12.82	4.21	0.90	0.17	0.02					19.58
	- 1/2							0.07	0.49	2.42	5.04	1.94	0.42	0.08	0.01					7.46
	- 5/8							0.03	0.17	0.81	1.94	0.85	0.22	0.03						2.75
	- 3/4							0.02	0.06	0.23	0.63	0.28	0.10	0.01						0.86
	- 7/8							0.02	0.03	0.06	0.09	0.03	0.00							0.14
	-1									0.01	0.01									0.02
	-1 1/4																			
	-1 1/2																			
	-1 3/4																			
	-2																			
TOTAL				0.01	0.05	0.24	1.27	8.02	89.64	2629.34	2650.66	94.50	7.76	0.90	0.10					

The distribution in Table 3 is asymmetric. For example, the likelihood of a simultaneous downward and outward 1/4-inch deviation is higher than an outward and upward deviation of the same magnitude.

Additional remarks on using the bivariate tables:

1. For Class 1 and 2 tracks, a very small amount of data was suitable for alignment and surface analysis (1.8 miles from Class 1 and 28 miles from Class 2 track, respectively). Therefore, bivariate tables are only provided for Class 2–8 tracks. Tables for Class 2 track should be used with caution due to the low mileage available for analysis.
2. “Inward” and “outward” in the bivariate tables are mentioned with respect to the track centerline, without regard to the inside/outside rail in curve.

3. The footages are per mile of rail, not per mile of track. Corresponding footages per mile of track are between 1 and 2 times the number in the table, depending on how likely a deviation is to occur in left and right rail simultaneously.
4. The tables show the average footage of exceedances per unit length, not the number of exceedances; the tables do not differentiate between one long exceedance and several short exceedances.
5. In addition to the FRA limits for alignment and surface deviations, limits on combined alignment and surface deviations may apply under certain conditions (49 CFR 213.65 and 213.332).
6. It must be stressed that, as with other characterization methods in this report, the distributions in these tables are averages for each track class in the analyzed dataset. The characteristics of individual sections of the same track class vary significantly.

6. Characterization in Frequency (Wavelength) Domain

6.1 Common Features

The research team cautions against interpreting every statistical difference between track classes as being entirely due to track class. When limited mileage is available for analysis, variations in the predominant traffic type, the type of fasteners used in a particular area, the properties of the TGMS used to collect the data, or other factors can easily overshadow the differences between track classes.

For example, when examining the PSD of every TG variable broken down by FRA track class, it is apparent that PSD curves of track Classes 6–8 follow the shape of PSD curves of track Classes 1–5 for wavelengths of ~10 feet and longer but not for shorter wavelengths (Figure 16). It may be tempting to conclude that this difference is caused entirely by track class. However, almost all of Class 6–8 data was collected by one track geometry car in a single railroad corridor connecting the Northeast and South regions of the United States. Also note that the mileage of track Classes 6–8 is much lower than that of other track classes. For a detailed discussion of this issue, see Appendix E.

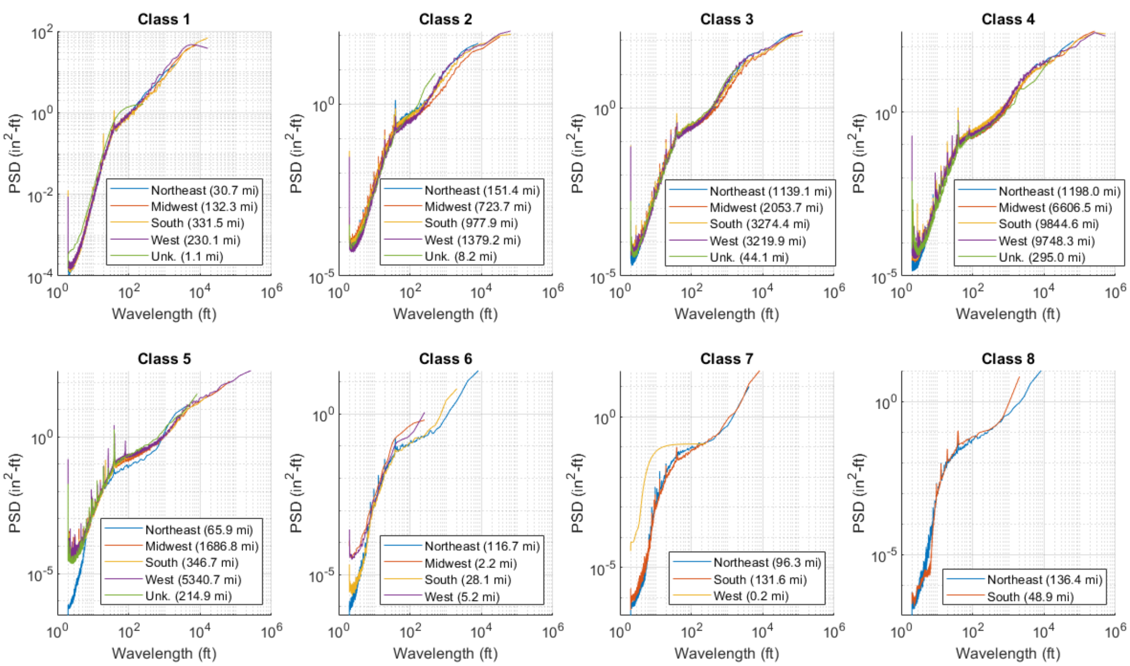


Figure 16. PSD of gage broken by track class and geographical region (note the 2–10 foot wavelength range)

6.2 Analysis of Individual TG Variables

6.2.1 Gage

For FRA track Classes 1–5, the shape of the track gage PSD resembles a bi-linear or tri-linear function on a logarithmic plot. A commonly stated assumption that PSDs of these track classes have the same shape but are "shifted" vertically with respect to each other is mostly correct for track Classes 1–5. However, the gage PSDs of track Classes 6–8 have more complex shapes (Figure 17). Potential causes of this difference are discussed in Appendix E.

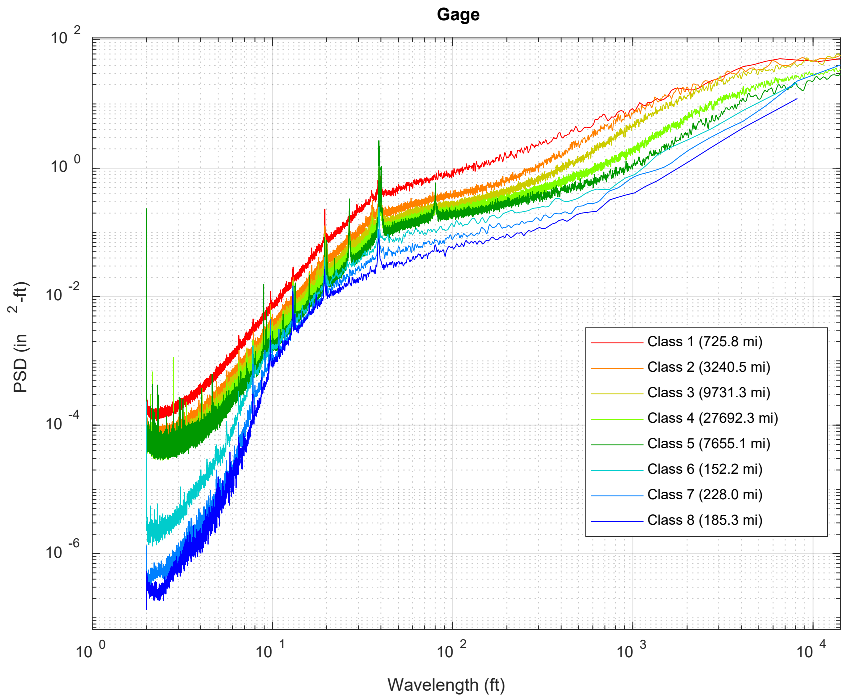


Figure 17. PSD plot of track gage by FRA track class

Frequency spikes associated with multiples and submultiples of rail length (80.3 feet, 39.0 feet, 26.8 feet, 19.6 feet, 16.0 feet, 13.0 feet, 9.8 feet, 7.8 feet, 6.5 feet) are seen in Figure 18.

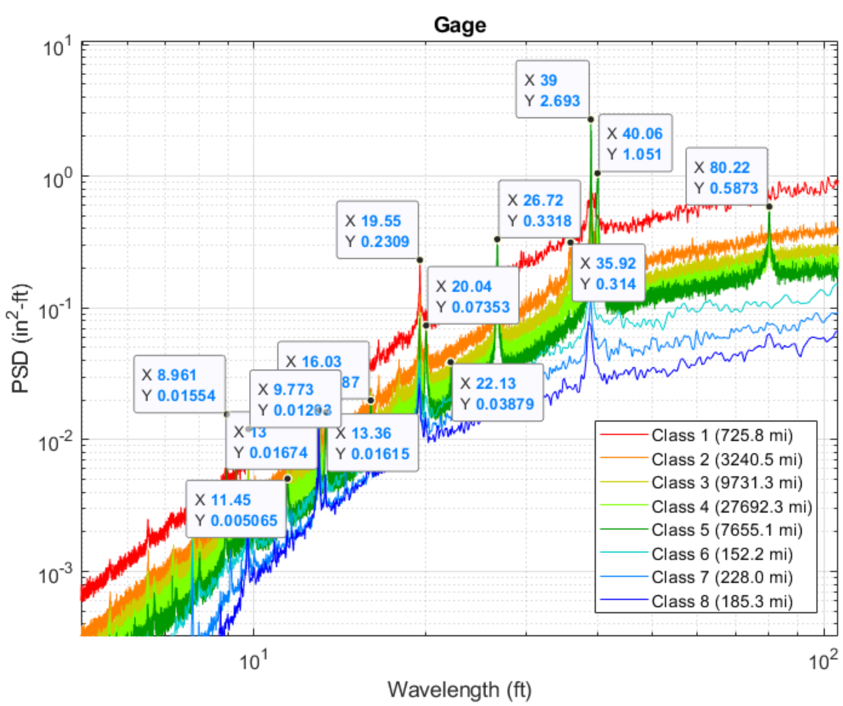


Figure 18. Locations of gage PSD peaks

However, not all these frequencies are present in every track class. The 80.3-foot wavelength, for example, is only noticeable in track Classes 4 and 5, as shown in Figure 19.

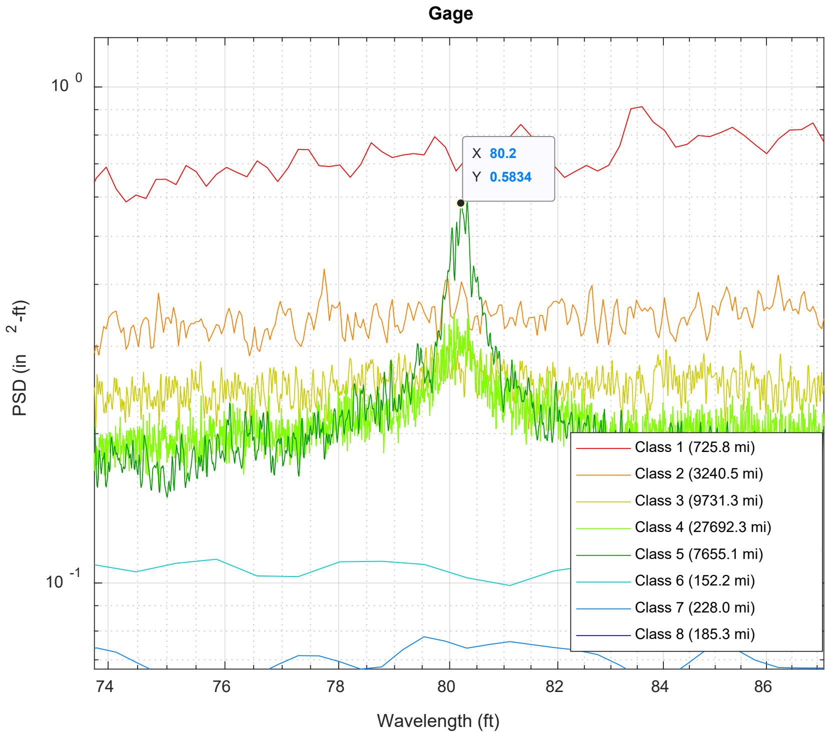


Figure 19. Gage PSD peak at 80.2 ft. wavelength

Table 4 lists the peak wavelengths from Figure 18 and compares them to the theoretical wavelength values calculated from nominal rail lengths of 39 and 80 feet.

Table 4. Gage PSD peaks

Rail Length Multiple	Calculated (ft)	Actual (ft)	Calculated (ft)	Actual (ft)
L	39.00	39.00	80.00	80.20
L/2	19.50	19.55	40.00	40.06
L/3	13.00	13.00	26.67	26.72
L/4	9.75	9.77	20.00	20.04
L/5	7.80	7.83	16.00	16.03
L/6	6.50	6.50	13.33	13.36
L/7	5.57	5.57	11.43	11.45

Interestingly, frequency spikes in track Classes 1 and 2 seem less prominent than in higher classes. A possible explanation is that in lower track classes, track irregularities associated with rail length are masked by stochastic irregularities that are more severe in higher track classes.

6.2.2 Cross level

The overall shape of the cross level PSD functions is similar to the gage PSD (Figure 20). However, frequency peaks are more prominent, and some of the peak wavelengths are different from the gage; for example, there are additional peaks at 33 and 36 feet in track Classes 1 and 2 while the peak at 80 feet is almost unnoticeable but its submultiples are still present (see Figure 21 and Table 5). In addition, the differences between the track cross level PSDs of track Classes 7 and 8 are more noticeable than the differences between gage PSDs of the same track classes (see Appendix E).

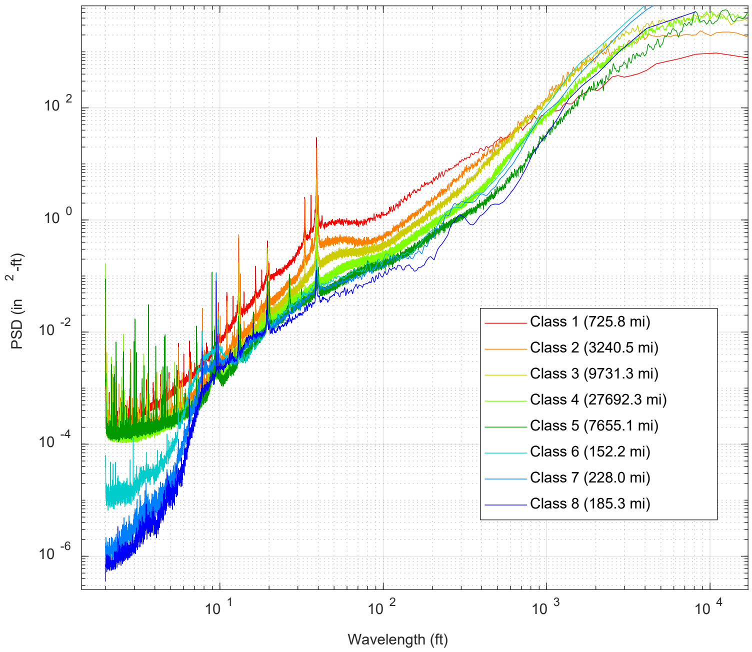


Figure 20. PSD plot of cross level by FRA track class

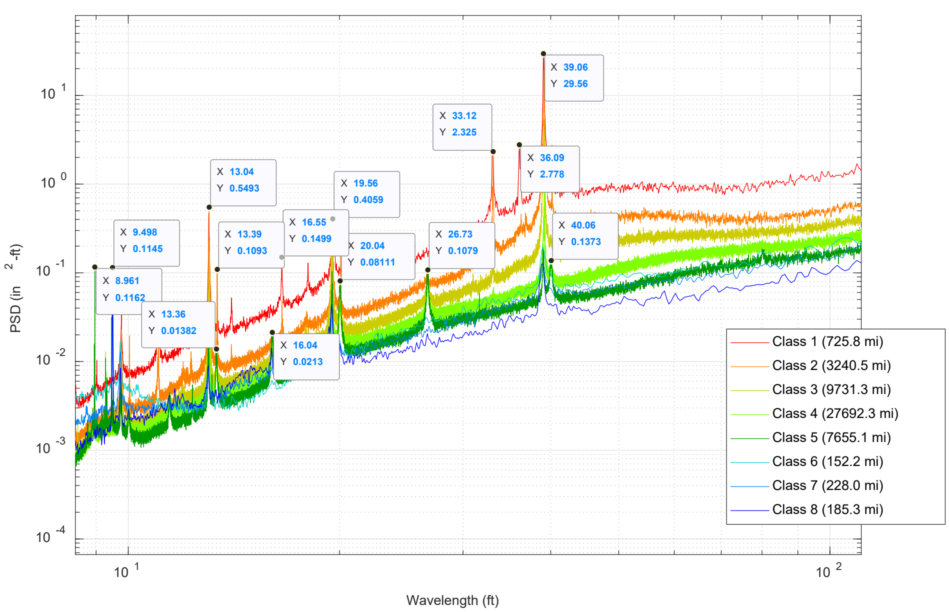


Figure 21. Locations of cross level PSD peaks

Table 5. Cross level PSD peaks

Wavelength Multiple	Calculated (ft)	Actual (ft)	Calculated (ft)	Actual (ft)
L	39.00	39.06	80.00	-
L/2	19.50	19.56	40.00	40.06
L/3	13.00	13.04	26.67	26.73
L/4	9.75	9.76	20.00	20.04
L/5	7.80	7.81	16.00	16.04
L/6	6.50	6.49	13.33	13.36
L/7	5.57	5.57	11.43	11.46

6.2.3 Mean Profile (Surface)

The PSD curves of the track centerline profile (i.e., mean track profile) have a more complex shape than the PSDs of other variables, and these curves could be approximated by 5 or 6 linear segments on a logarithmic plot (Figure 22). Note that wavelengths longer than 400 feet are beyond the cutoff length of the filter used by the track geometry cars.

Peak frequencies are similar to other variables described earlier. However, the peaks in Class 2 track are not very pronounced, e.g., a 39-foot peak in Class 2 track is nearly unnoticeable, possibly due to computational reasons (the short length available for analysis, as compared with other track classes). In addition to the submultiples of standard rail lengths, several other frequencies (33 feet, 16.6 feet) are noticeable (Figure 23 and Table 6). A discussion of the differences between Class 1–5 and Class 6–8 data can be found in Appendix E.

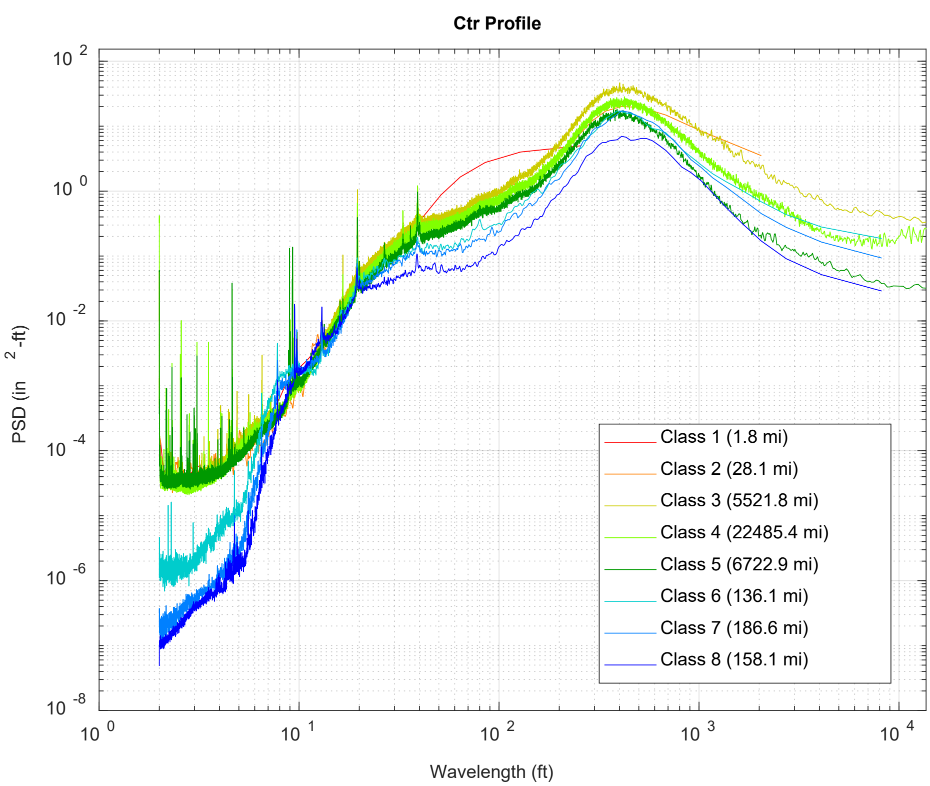


Figure 22. PSD estimates of mean track profile by FRA track class

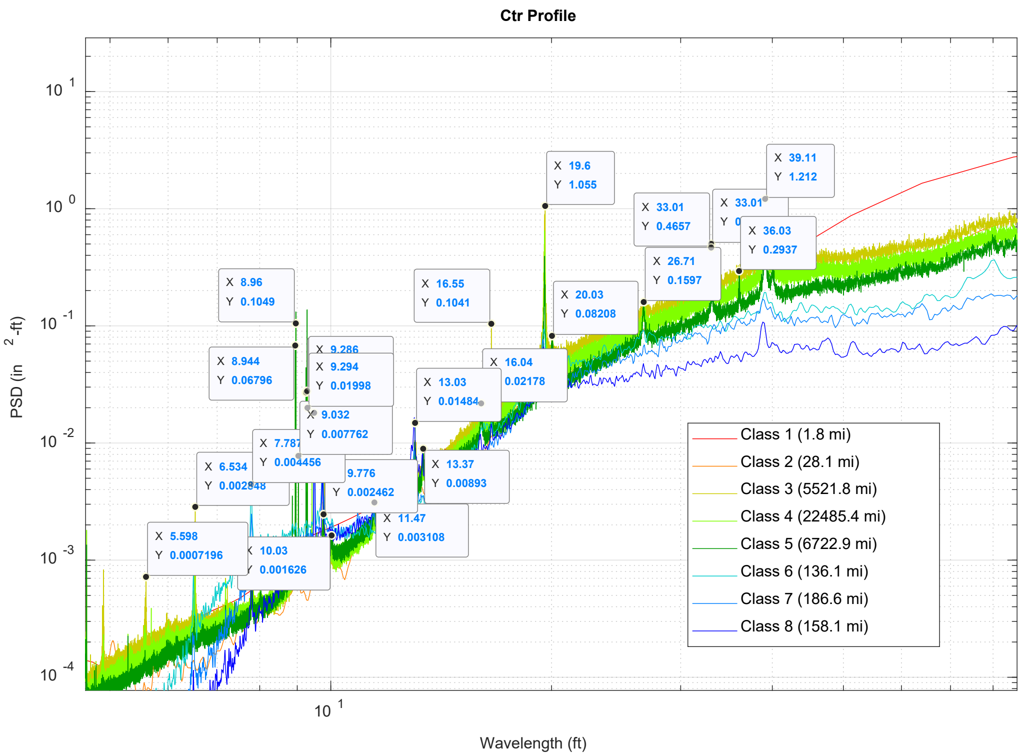


Figure 23. Locations of mean profile PSD peaks

Table 6. Mean profile PSD peaks

Wavelength Multiple	Calculated (ft)	Actual (ft)	Calculated (ft)	Actual (ft)
L	39.00	39.11	80.00	-
L/2	19.50	19.60	40.00	40.11
L/3	13.00	13.03	26.67	26.71
L/4	9.75	9.78	20.00	20.03
L/5	7.80	7.79	16.00	16.04
L/6	6.50	6.53	13.33	13.37
L/7	5.57	5.60	11.43	11.47

6.2.4 Mean Alignment

The centerline alignment (i.e., mean track alignment) PSD differs from the PSDs of other TG variables in that frequency spikes are very prominent in track Classes 4–8 but are barely noticeable in track Classes 2–3 (Figure 24). The frequency spikes associated with a 39-foot and 80-foot wavelength as well as their submultiples are shown in Figure 25 and Table 7. As with other TG variables, the data from Class 6–8 track show some unique patterns (see Appendix E). Similar to the surface space curve, the wavelengths longer than 400 feet are beyond the cutoff length of the filter used by the track geometry cars.

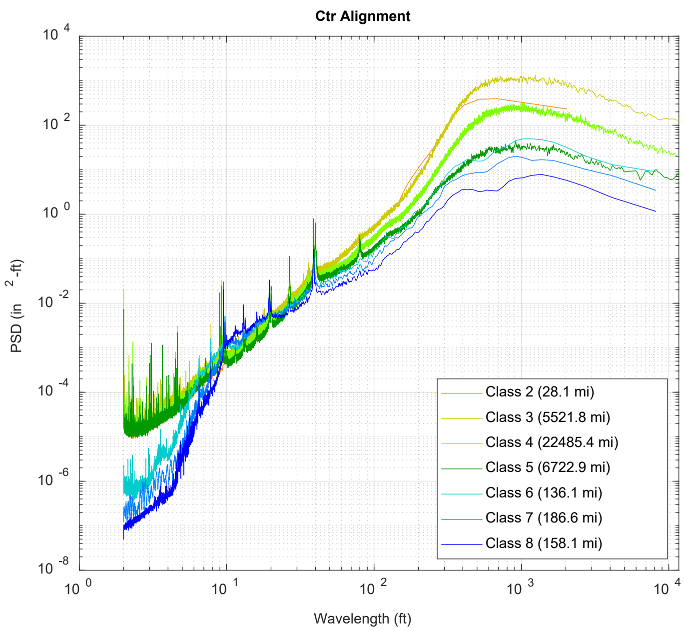


Figure 24. PSD estimates of mean track alignment by FRA track class

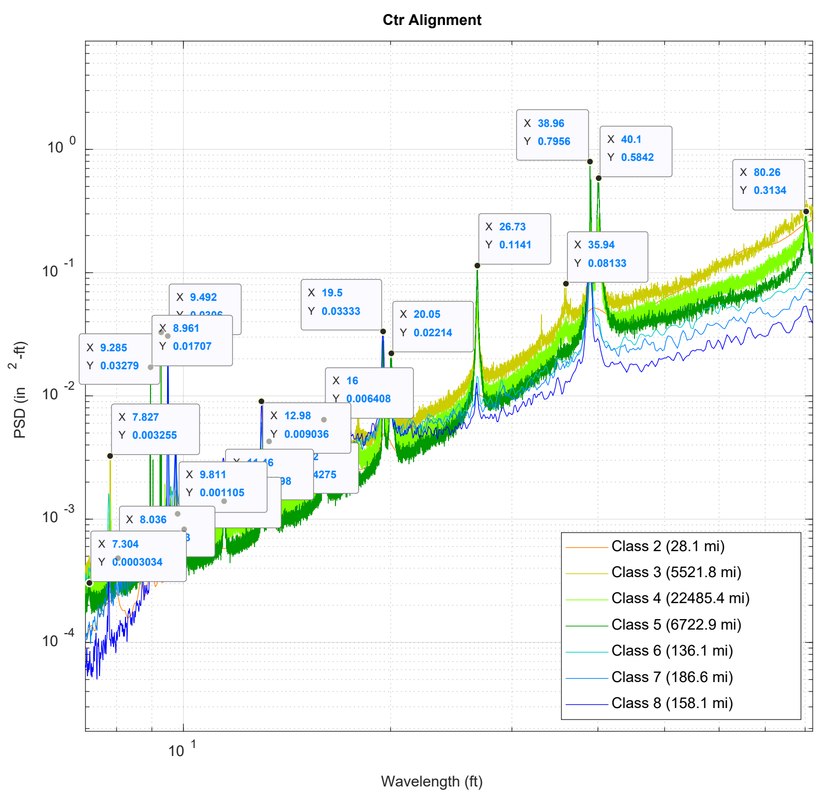


Figure 25. Locations of mean alignment PSD peaks

Table 7. Mean alignment PSD peaks

Wavelength Multiple	Calculated (ft)	Actual (ft)	Calculated (ft)	Actual (ft)
L	39.00	38.96	80.00	80.26
L/2	19.50	19.50	40.00	40.10
L/3	13.00	12.98	26.67	26.73
L/4	9.75	9.81	20.00	20.05
L/5	7.80	7.83	16.00	16.00
L/6	6.50	6.52	13.33	13.32
L/7	5.57	5.59	11.43	11.46

6.2.5 Left and Right Profile and Alignment

The PSDs of the left and right rail profiles are essentially combinations of PSDs of mean profile and cross level. Similarly, the PSDs of left and right alignment are combinations of the PSDs of gage and mean alignment.

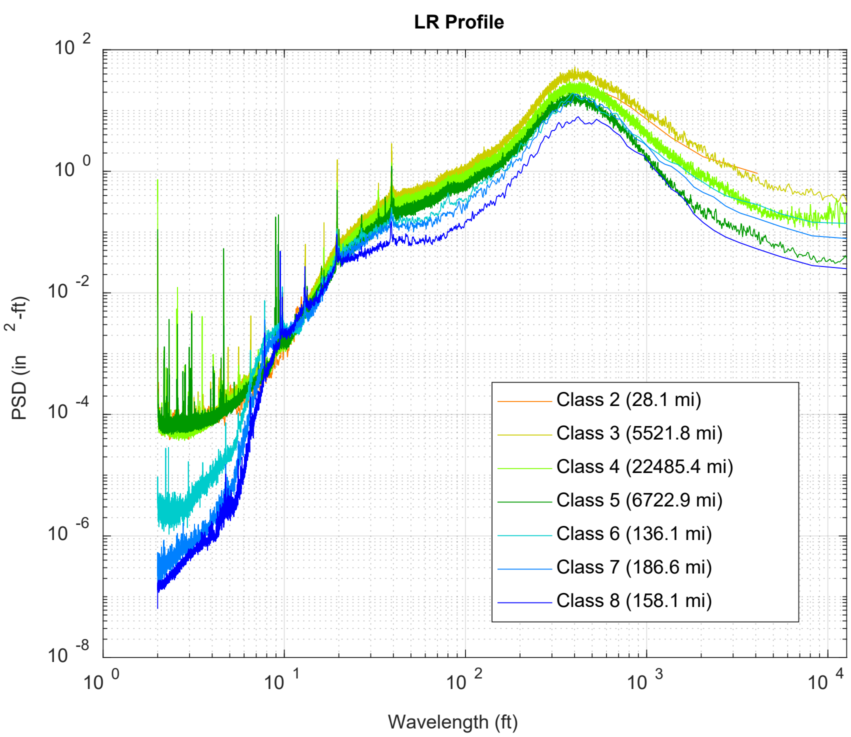


Figure 26. PSD of L&R rail profile by FRA track class

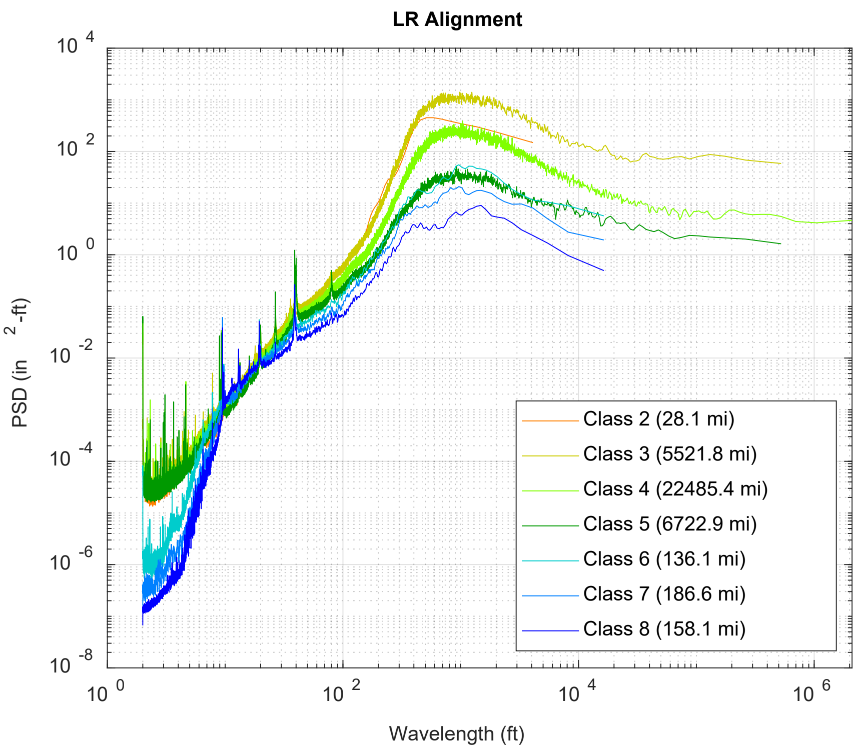


Figure 27. PSD of L&R rail alignment by FRA track class

6.3 Coherence

As expected, the four principal variables (i.e., gage, cross level, mean alignment, and mean profile) show very low coherence (Figure 28), confirming the conclusions of the previous studies (Corbin, 1980a; Haigermoser, Luber, Rauh, & Grafe, 2015).

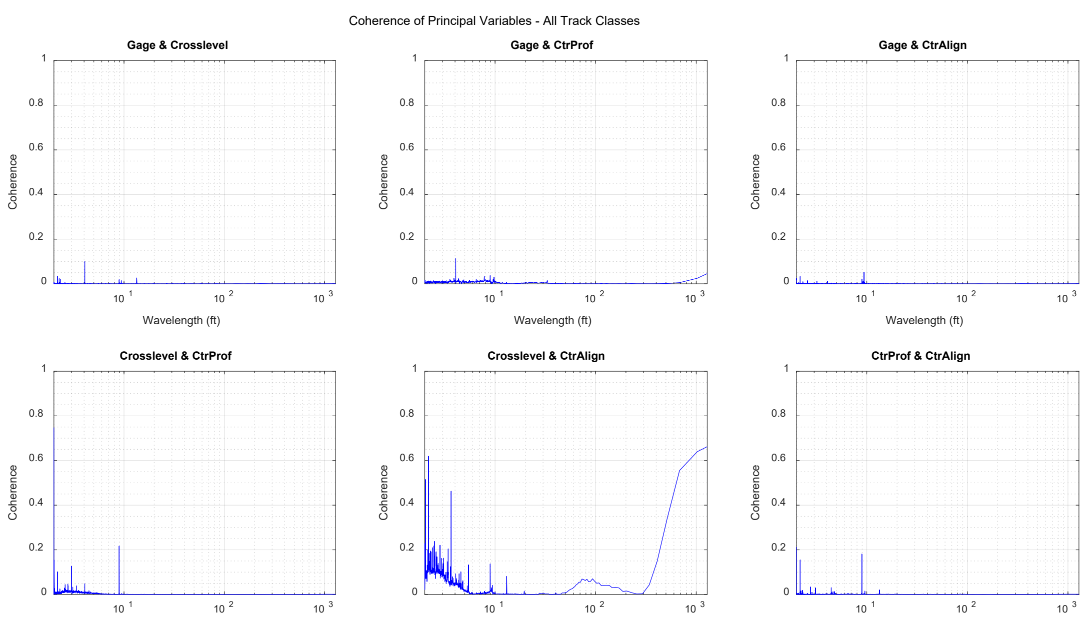


Figure 28. Coherence of principal track geometry variables

These studies showed that the four principal variables are largely independent, except for track irregularities associated with submultiples of rail length (as evident from coherence spikes at those frequencies). Even for those irregularities the coherence is rather low.

At track Classes 6–8, there is a higher coherence between mean alignment and cross level at wavelengths 3–20 feet (up to ~0.7) and a lower but still notable coherence (~0.2) at wavelengths 10–100 feet (Figure 29). Appendix E has a discussion of these differences.

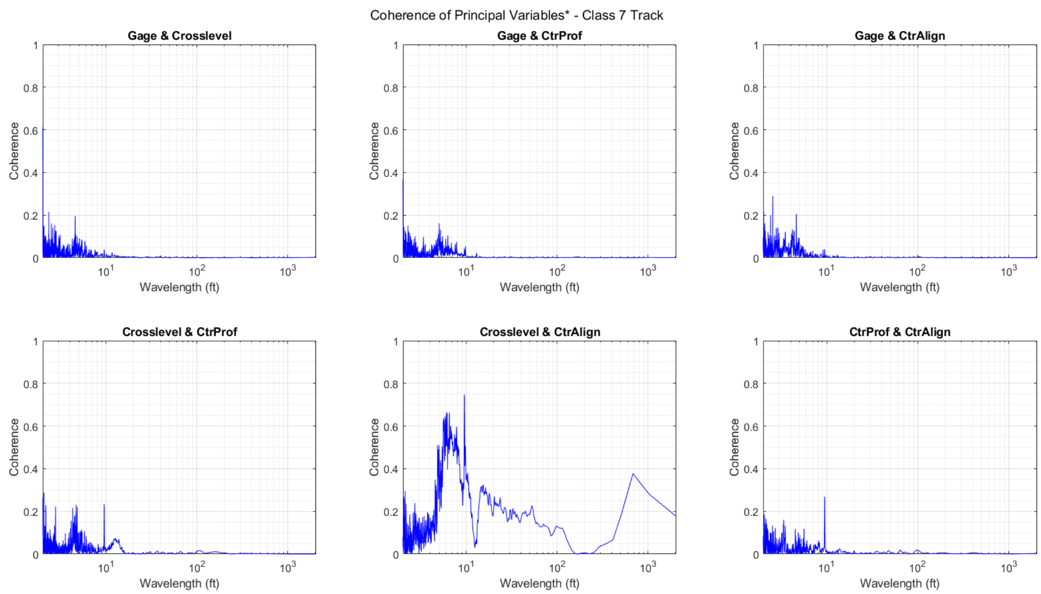


Figure 29. Coherence of principal track geometry variables for Class 7 track

The coherence between the left and right surface (i.e., profile) is low at small wavelengths (<10 feet) but quickly increases and stays above 60 percent for wavelengths over ~20 feet (Figure 30). In other words, long-wavelength vertical irregularities in left and right rail tend to happen synchronously.

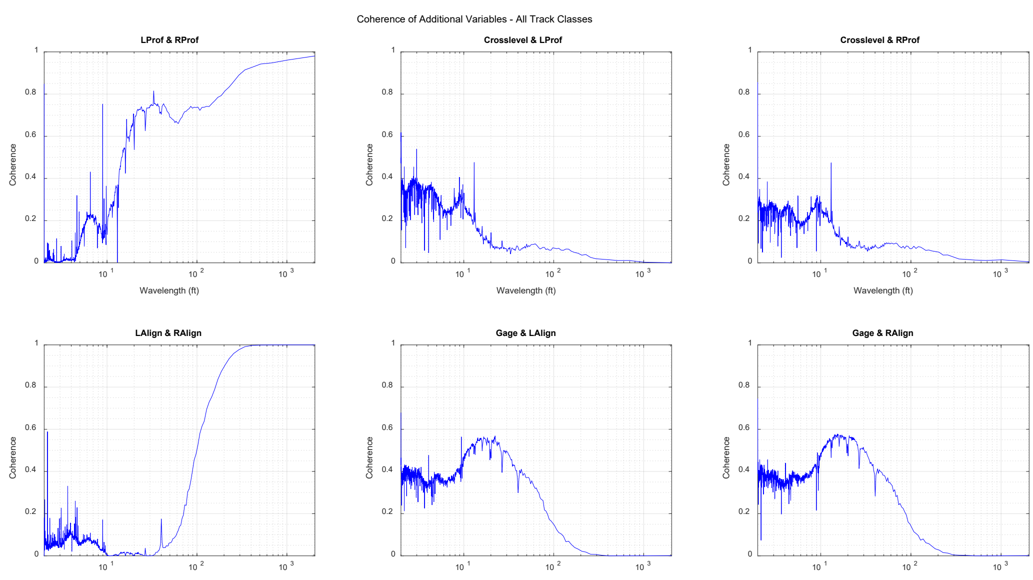


Figure 30. Coherence of additional track geometry variables

The coherence between left and right alignment stays below 0.2 for wavelengths <70 feet and quickly increases from there, reaching 0.9 at ~200 feet. This indicates that the left and right rail alignment tend to be independent of each other at short wavelengths, i.e., short-wavelength left and right lateral alignment irregularities are due to gage changes rather than track alignment errors.

The coherence between profile and alignment in the same rail is low, i.e., vertical and lateral track irregularities are largely independent of each other (Figure 31 and Figure 32). However, there are small coherence spikes at rail length (39 feet) and its submultiples, implying a weak correlation between lateral and vertical track irregularities associated with rail length.

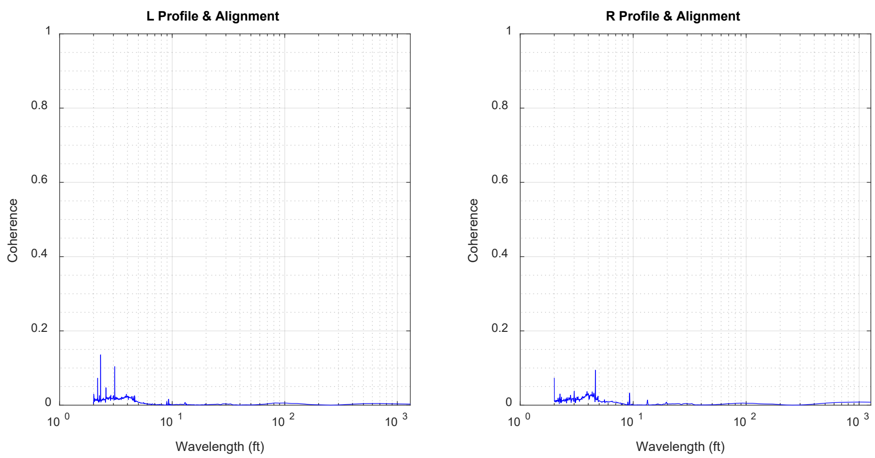


Figure 31. Coherence of L&R alignment and profile

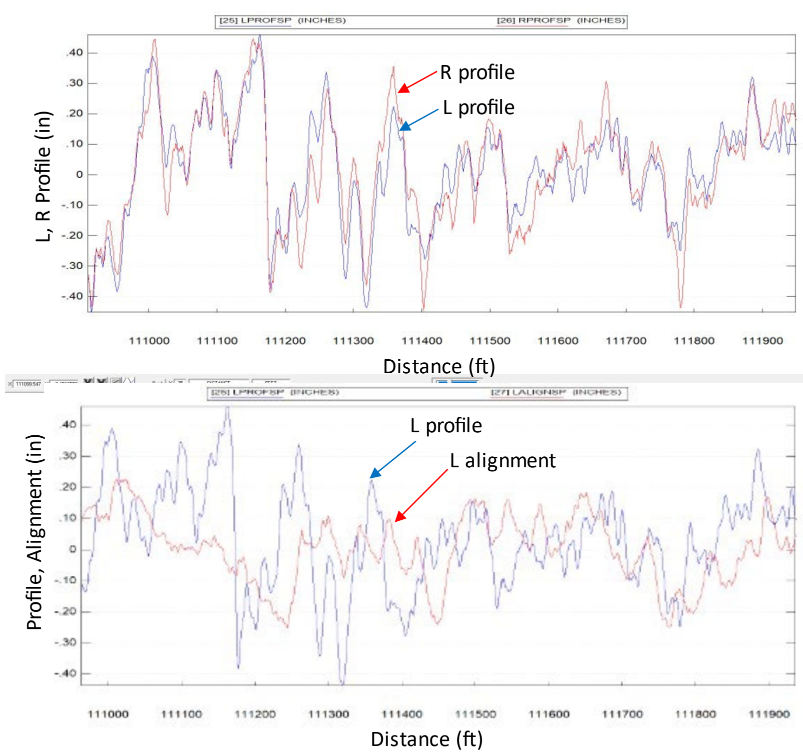


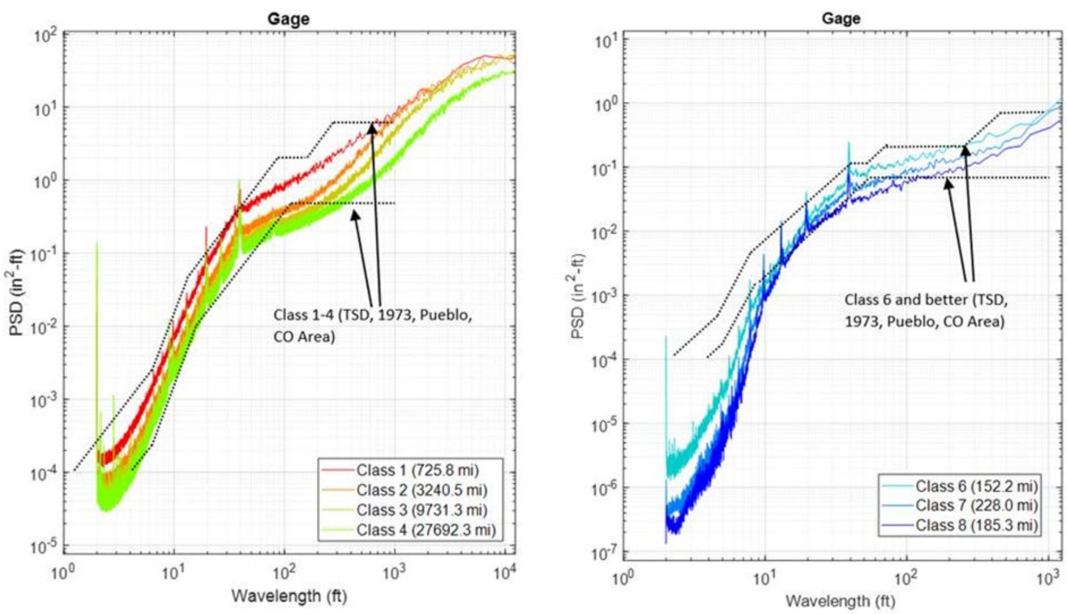
Figure 32. L&R rail profile plots typical of FRA Class 5 track

6.4 Comparison with Track Geometry Data Collected in the 1970s

6.4.1 Comparison of PSD Continuum

The appendices to FRA Report ORD-83/03.2 (Hamid et al., 1983a) contain a series of PSD plots of track geometry collected in the 1970s (a total of 150 miles). Some of the information was from measurements made with track geometry car T-3 in the Northeast Area of the US (NEA), and some was from measurements made with a track Surveying Device (TSD) in the Pueblo, Colorado, area. Note that the Class 6 track measured in Pueblo was probably at the TTC, and therefore, it may not be representative of revenue service track.

The plots in Figure 33 to Figure 36 show the overlays of the PSDs of the current data set with the PSD plots from the 1970s. For readability, only the ranges of the PSD continuum functions from several track classes are shown. The continuum of the PSD plots illustrates the overall roughness of track geometry in different wavelength ranges. For a more detailed view of PSDs, including the locations of PSD spikes, see Report DOT/FRA/ORD-83/03.2, Appendix B (Hamid et al., 1983a).



Track Surveying Device, 1973, Class 1-4 vs. Current Data

Track Surveying Device, 1973, Class 6+ vs. Current Data

Figure 33. Comparison of track gage PSD continuum from 1970s and 2010s

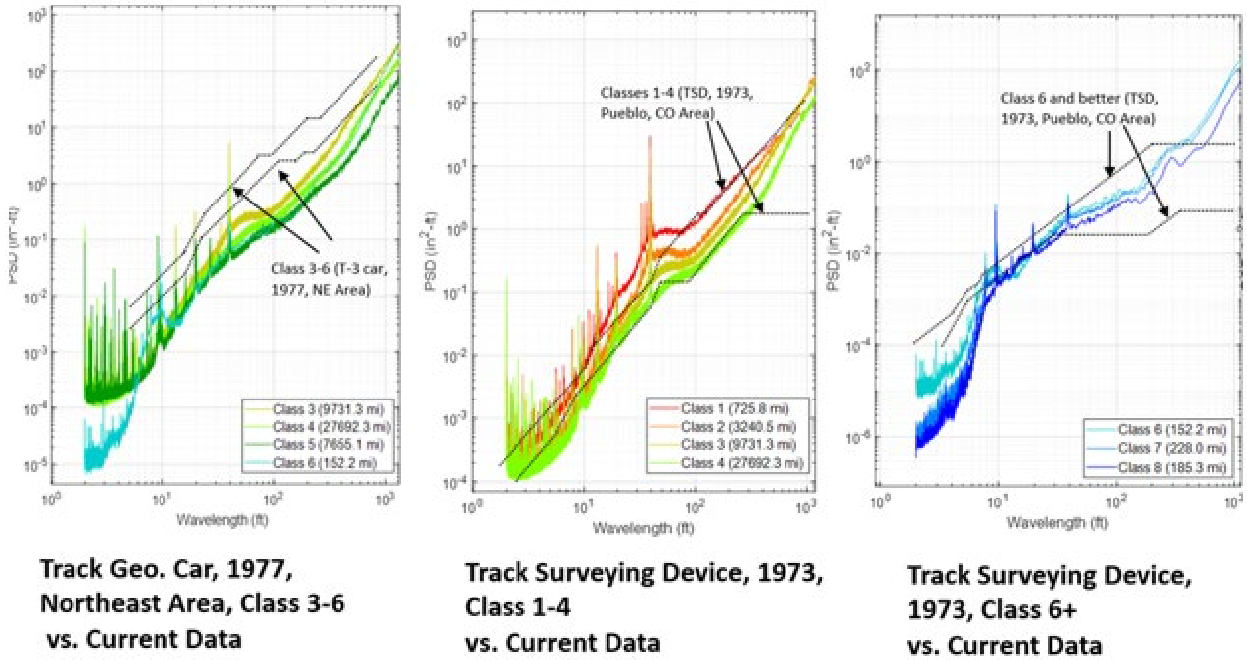


Figure 34. Comparison of cross level PSD continuum from 1970s and 2010s

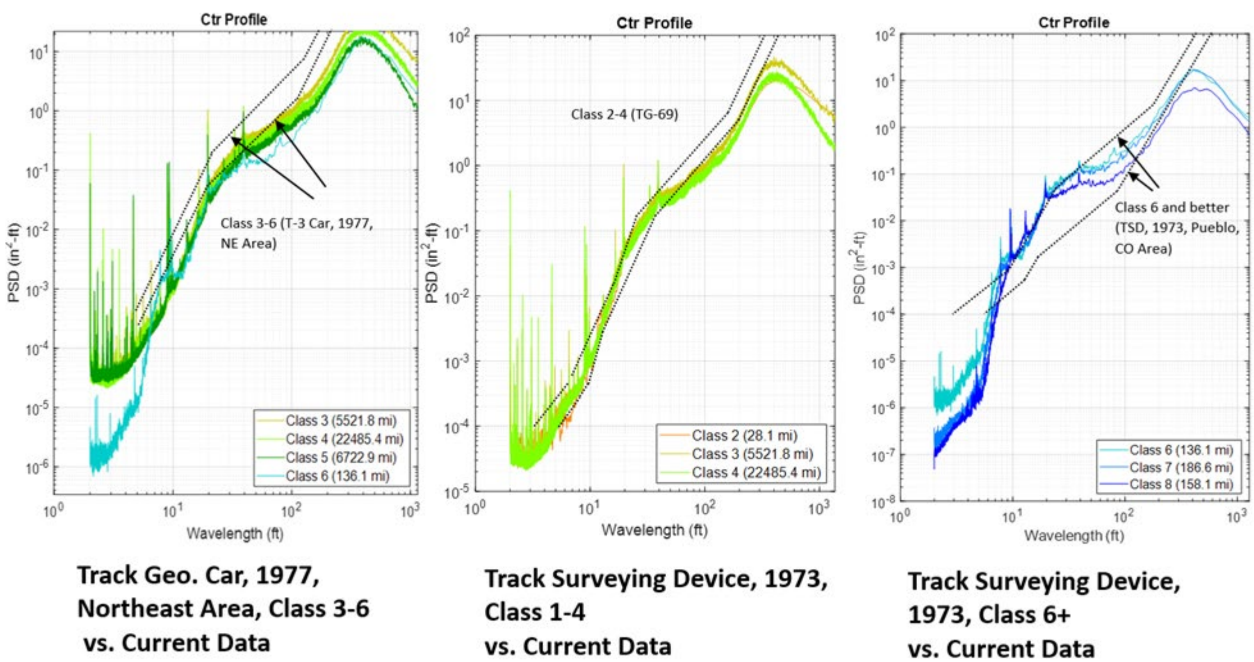


Figure 35. Comparison of mean profile PSD continuum from 1970s and 2010s

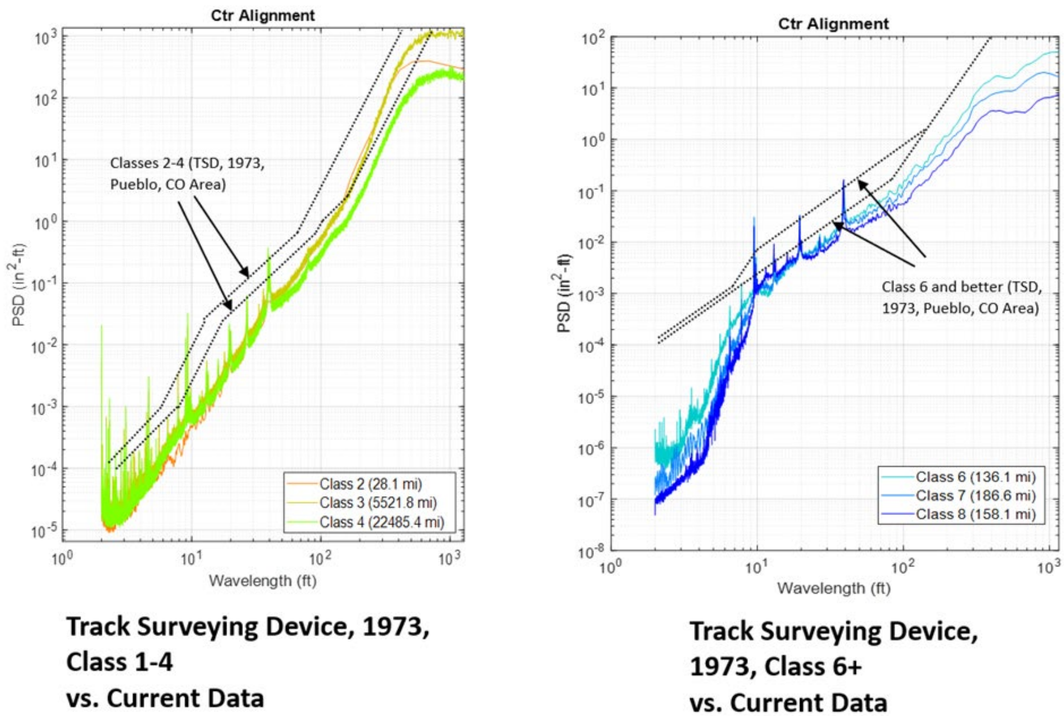


Figure 36. Comparison of mean alignment PSD continuum from 1970s and 2010s

The overlays indicate that:

- Overall roughness of track **gage** is similar between TSD measurements in 1973 and ATIP and Amtrak cars' measurements in 2010s (track Classes 1–4 and 6+).
- Overall roughness of track **cross level** is similar between TSD measurements in 1973 and ATIP and Amtrak cars' measurements in the 2010s (track Classes 1–4 and 6+). However, the measurements by the T-3 car in 1977 (track Classes 3–6) show an overall roughness that is substantially higher than what was measured by ATIP cars in the 2010s.
- Overall roughness of **mean profile** is similar between TSD measurements in 1973 and ATIP and Amtrak cars' measurements in the 2010s (track Classes 1–4 and 6+). However, the measurements by the T-3 car in 1977 (track Classes 3–6) show an overall roughness that is somewhat higher than what was measured by ATIP cars in the 2010s.
- The **mean alignment** measurements by TSD in 1973 (track Classes 2–4 and 6+) show an overall roughness that is higher than what was measured by ATIP and Amtrak cars in the 2010s.

The differences between the 1970s and 2010s measurement may be caused by:

- Changes in traffic patterns and/or track maintenance practices over the last 40 years
- Regional differences (the 1970s data was from a small dataset from specific regions, whereas the 2010s data was collected throughout the entire United States rail system)
- Differences in track geometry measurement methodology and equipment in the 1970s and the 2010s (see Appendix E for additional considerations for Class 6–8 track data)

It is impossible to say with certainty which of these causes is more prevalent.

6.4.2 Comparison with 1980s PSD Parametrization Functions

In the 1980s, a series of parametrization functions for PSDs of track geometry variables were proposed (Corbin, 1980b; Hamid et al., 1983b) These functions were based on polynomial approximations of PSD continuum estimated using the measurements made with the T-3 car and the TSD.

Figure 37 to Figure 40 show these parametrization functions overlaid on the current (2012–2019) dataset. The key observations are:

- The parametrization functions for gage generally match the new gage data in the 10–40-foot wavelength range. For the 40–500-foot wavelength range, parametrization functions estimate higher gage roughness than recent measurements.
- The parametrization functions for cross level show a good match in the 40–100-foot wavelength range. These functions tend to underestimate the cross level roughness at the 10–40-foot wavelength range and over 200-foot wavelengths, compared to the new data.
- Compared to the new data, the parametrization functions for mean profile and mean alignment tend to overestimate the roughness of these variables as well as the differences between track classes (see Appendix E for special considerations for Class 6–8 data).

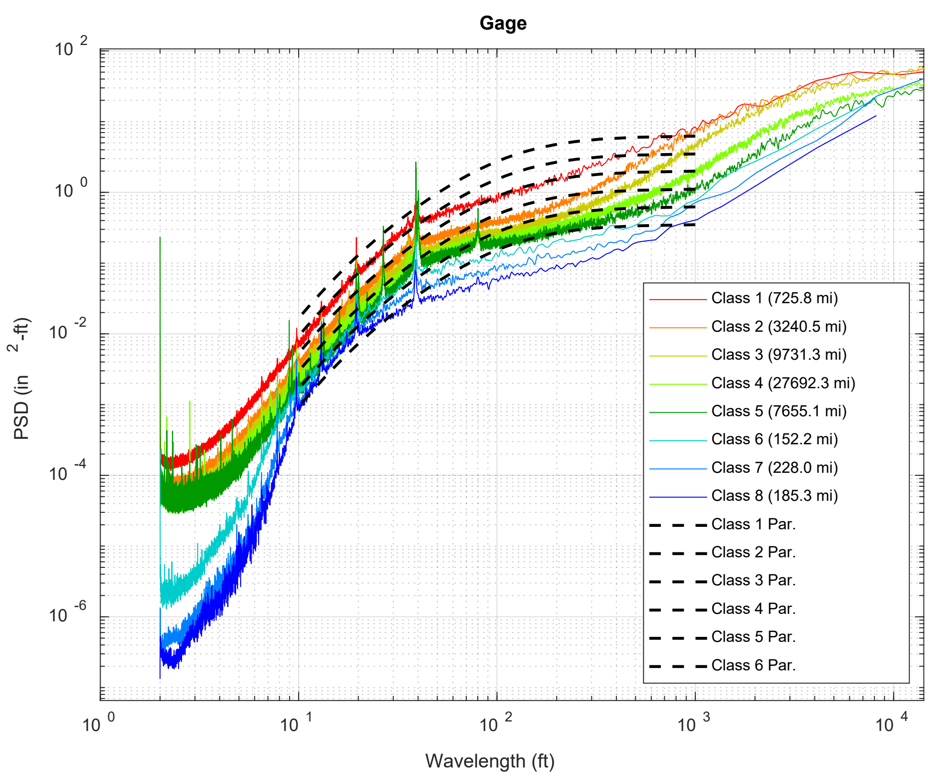


Figure 37. PSD of gage and its parametrization functions proposed in 1980s

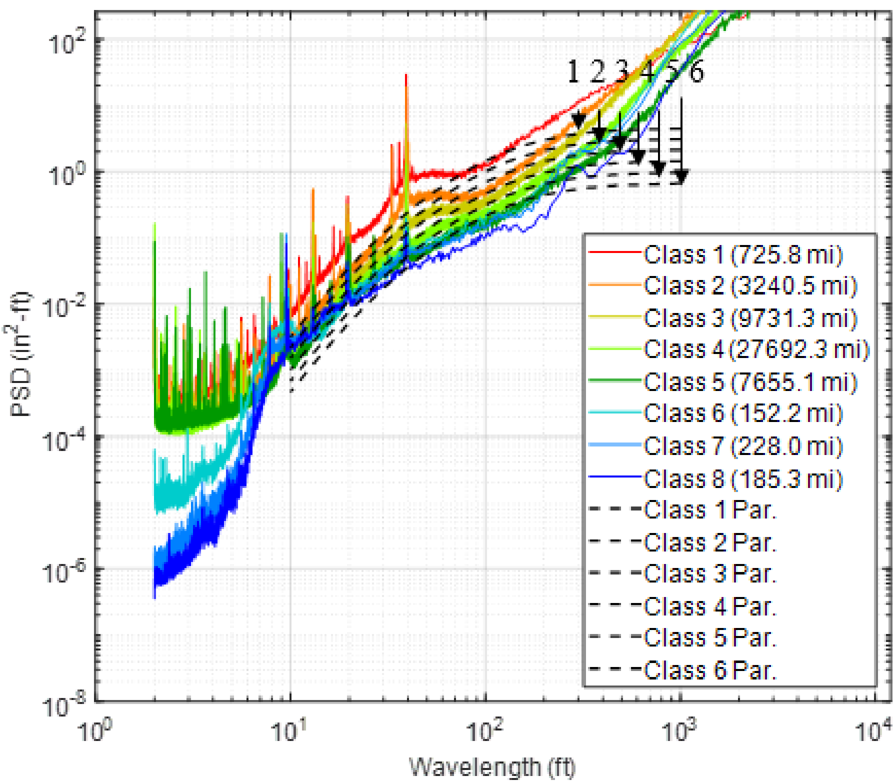


Figure 38. PSD of cross level and its parametrization functions proposed in 1980s

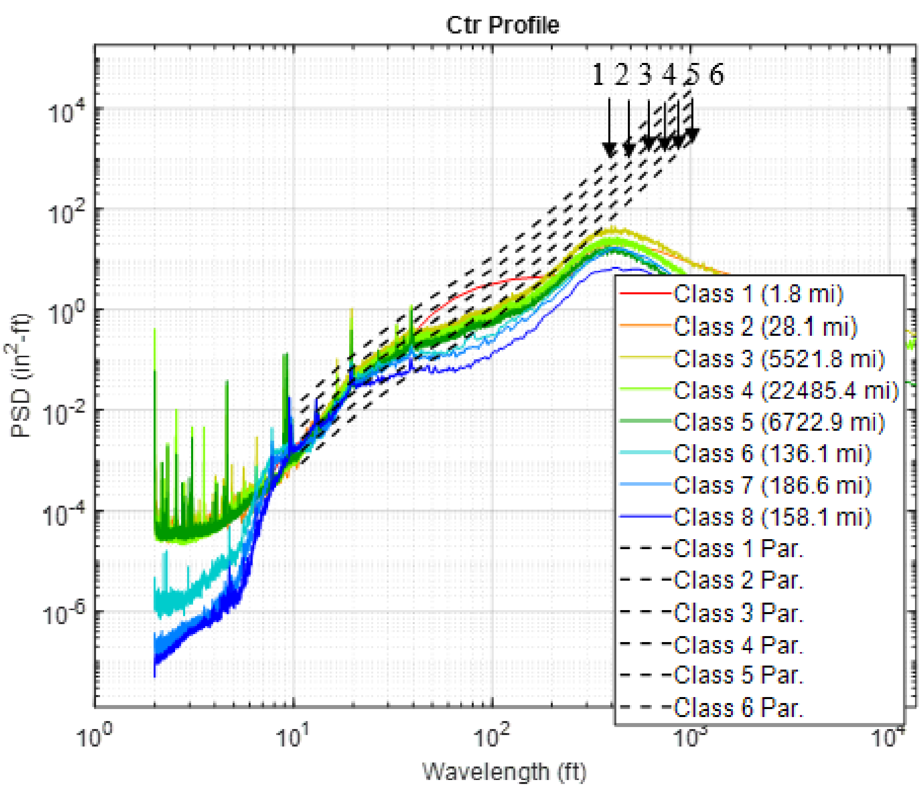


Figure 39. PSD of mean profile and its parametrization functions proposed in 1980s

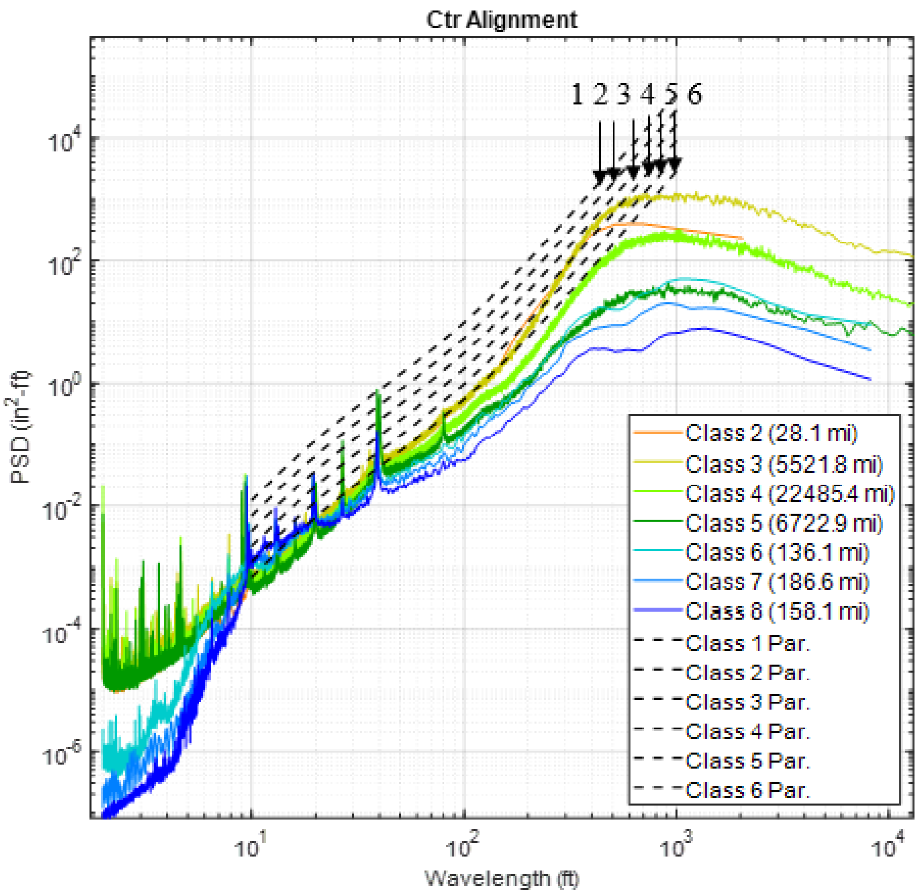


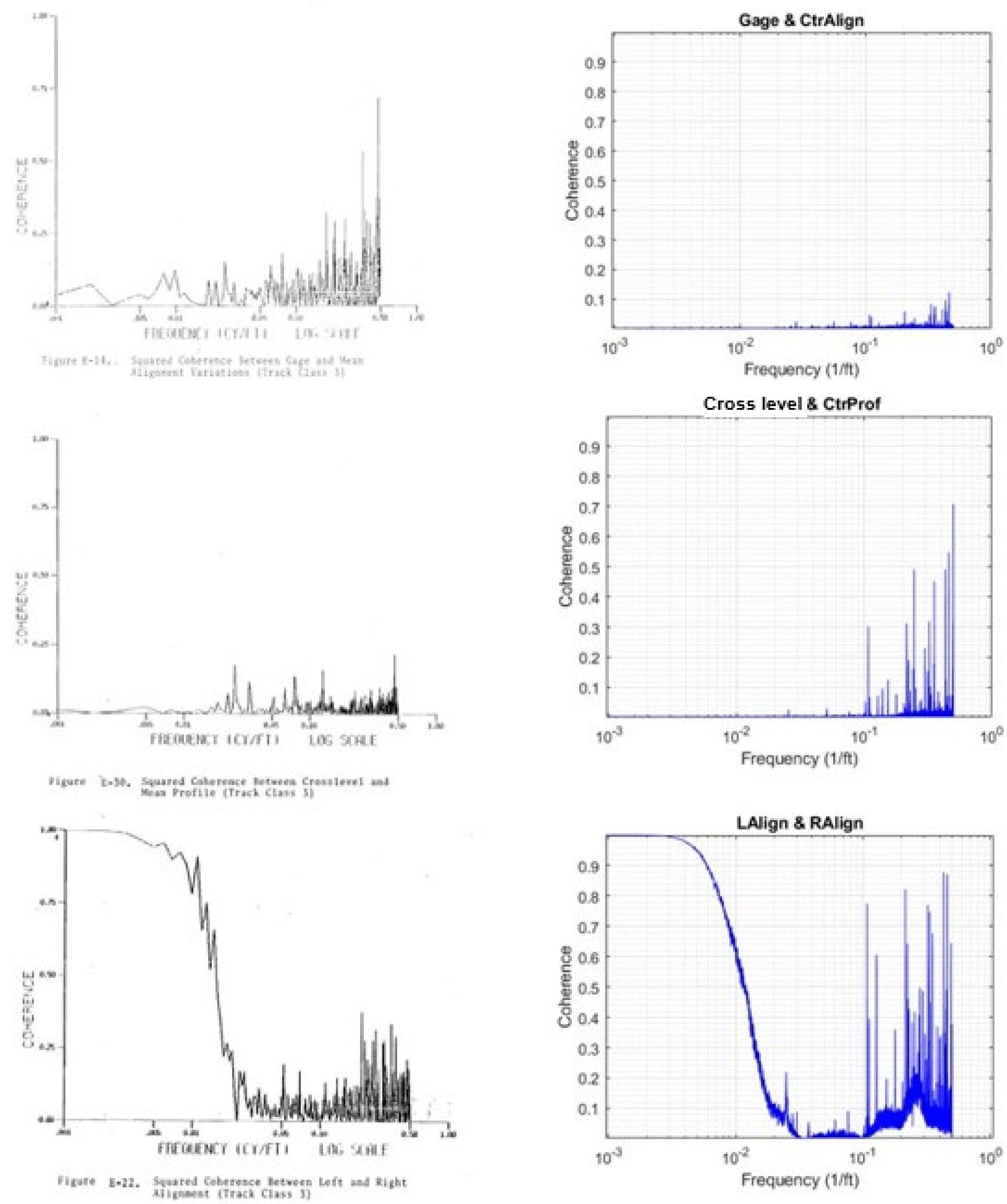
Figure 40. PSD of mean alignment and its parametrization functions proposed in 1980s

6.4.3 Comparison of Coherence Plots

The comparisons of coherence between the TG variables calculated in the 1980s study and in the current study are made in Figure 41 and Figure 42. These comparisons show that:

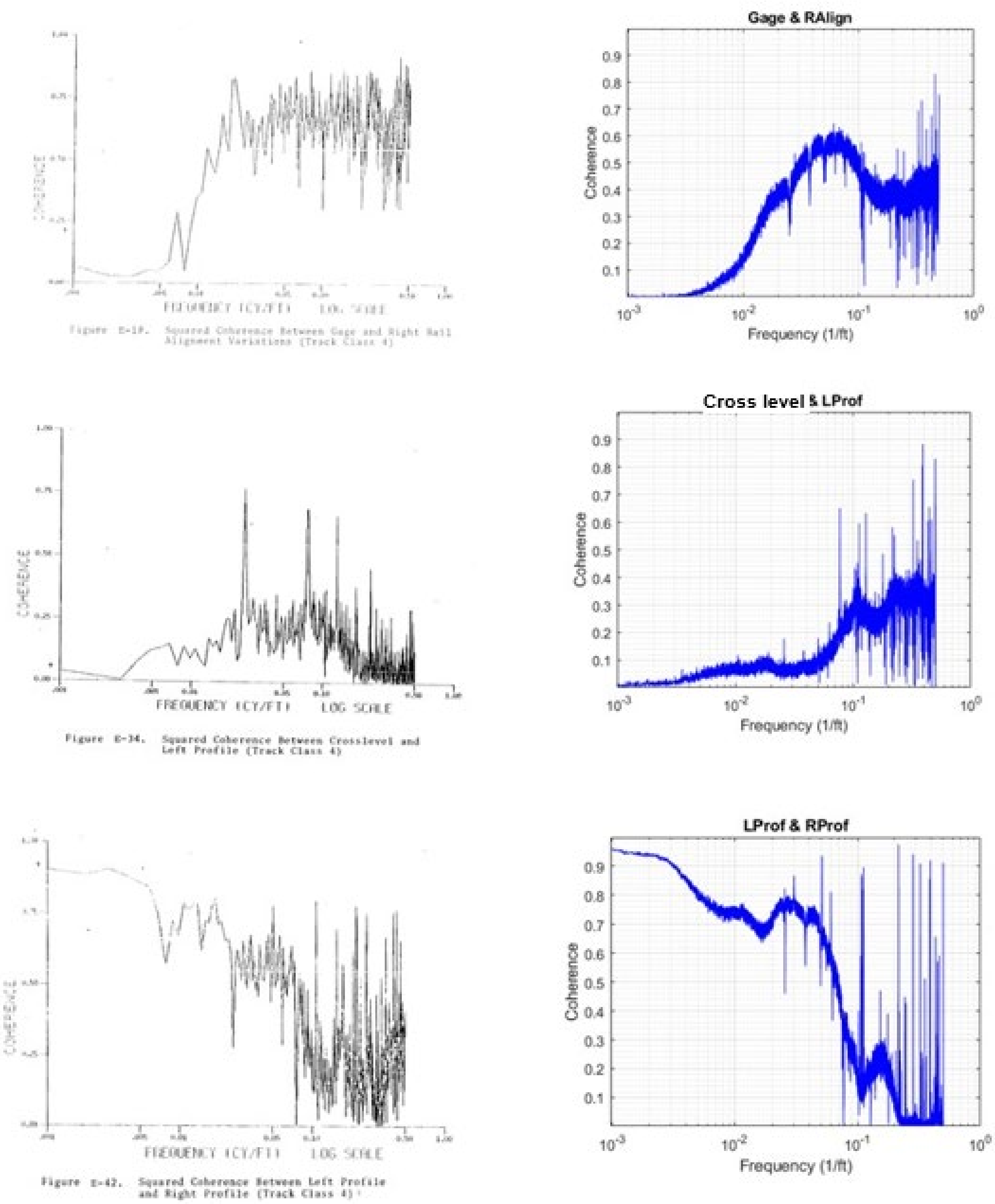
- Coherence between gage and mean alignment is generally very low both in the 1980s study and in the current study. This also holds true for the coherence between the cross level and the mean profile.
- Coherence between left and right alignment shows similar patterns in a 1980s study (Hamid et al., 1983b) and in the current study, with coherence being low at shorter wavelengths (i.e., below ~100 feet) and high at long wavelengths. This also holds true for the coherence between the left and right profile, except coherence remains high at wavelengths as short as ~20 feet.
- The coherence between gage and left/right rail alignment remains between 0.4~0.6 for wavelengths shorter than ~50 feet both in the 1980s study and in the current study, although the exact shape of the coherence function differs somewhat.
- The coherence between the cross level and the left/right profile has a different shape between the 1980s and the current study. In either case, however, it remains below 0.4

(except for spikes associated with submultiples of rail length) for the entire frequency spectrum.



Source of 1980s data: (Hamid et al., 1983b)

Figure 41. Comparison between coherence functions based on 1980s (left) and 2010s (right) data; Class 3 track



Source of 1980s data: (Hamid et al., 1983b)

Figure 42. Comparison between coherence functions based on 1980s (left) and 2010s (right) data; Class 4 track

7. Characterization Using Clustering

7.1 Methodology

Clustering is a machine learning method based on dividing a population of objects into clusters (i.e., groups) such that the objects in each cluster are similar to each other. The most commonly used measure of similarity is the Euclidean distance between the members of the population.

Two of the most common clustering algorithms are hierarchical clustering and k-means clustering. Hierarchical clustering requires calculating the similarity between each combination of two objects; it yields repeatable results and allows determining the optimal numbers of clusters (MathWorks, 2021). This type of clustering, however, is very demanding with respect to both memory and execution time; therefore, it is poorly suited for the analysis of large data sets. In k-means clustering, the user must first define the number of clusters, which may or may not be ideal for the problem in question. The algorithm then determines the initial grouping of the objects randomly (or using a k-means++ algorithm), and then it iteratively optimizes the grouping of objects between clusters. K-means clustering is more computationally efficient than hierarchical clustering, but its results are not reproducible and may not be optimal (MathWorks, 2021).

As applicable to track geometry, each object (i.e., member of population) is a specific track irregularity, and each group is a shape that is common to many irregularities. Thus, clustering identifies typical shapes of track irregularities and classifies each irregularity to one of these shapes.

The method used in this study is adapted from Kraft et al. (2015). It is implemented in a modified form as follows:

1. Local peaks and troughs (i.e., minima and maxima) are found using MATLAB's built-in *findpeaks* function.
2. Peaks and troughs are classified into major and minor categories based on their prominence. The prominence threshold is determined empirically.
3. Each individual irregularity is centered at a major peak/trough and extends to the nearest minor peaks/troughs. If several major peaks/troughs are encountered in a row, each major peak/trough constitutes a center of a separate irregularity, and therefore, the same waveform may be considered a part of more than one irregularity.

To find complex irregularity shapes, an irregularity may be extended by two, three, or more minor peaks/troughs in each direction. This is shown in Figure 43.

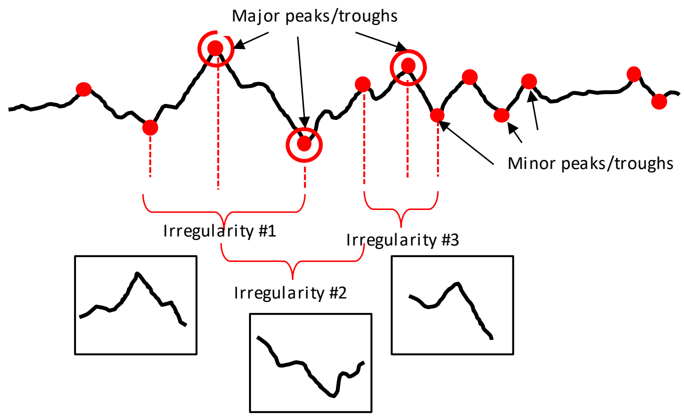


Figure 43. Track irregularity boundaries

4. Irregularities are "padded"/extended with zeros such that the length of each irregularity equals the length of the longest irregularity in the dataset. This padding is done so a Euclidean distance between each two irregularities can be calculated.
5. Irregularities are normalized by their peak-to-peak amplitude.
6. Normalized irregularities are grouped into clusters (i.e., typical shapes). If hierarchical clustering is used, the number of clusters is determined by the visual inspection of a dendrogram. If k-means++ clustering is used, the number of clusters is determined by trial and error and engineering judgment. Figure 44 and Figure 45 show results for the same dataset analyzed with a different number of clusters. Translucent blue plots represent normalized individual track irregularities, and solid red plots are averaged irregularity shapes.

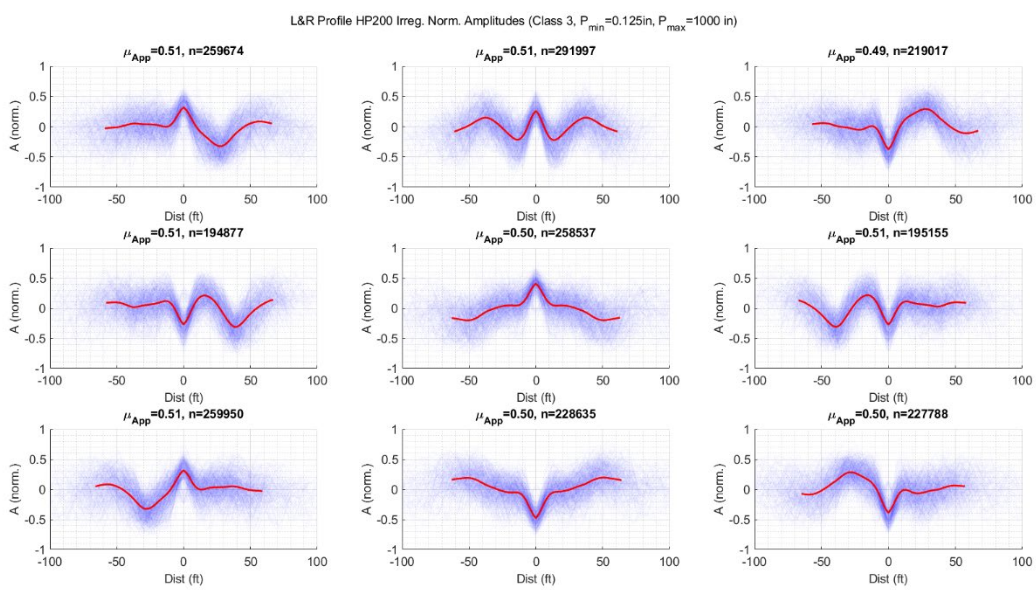


Figure 44. Vertical track irregularities separated into nine clusters

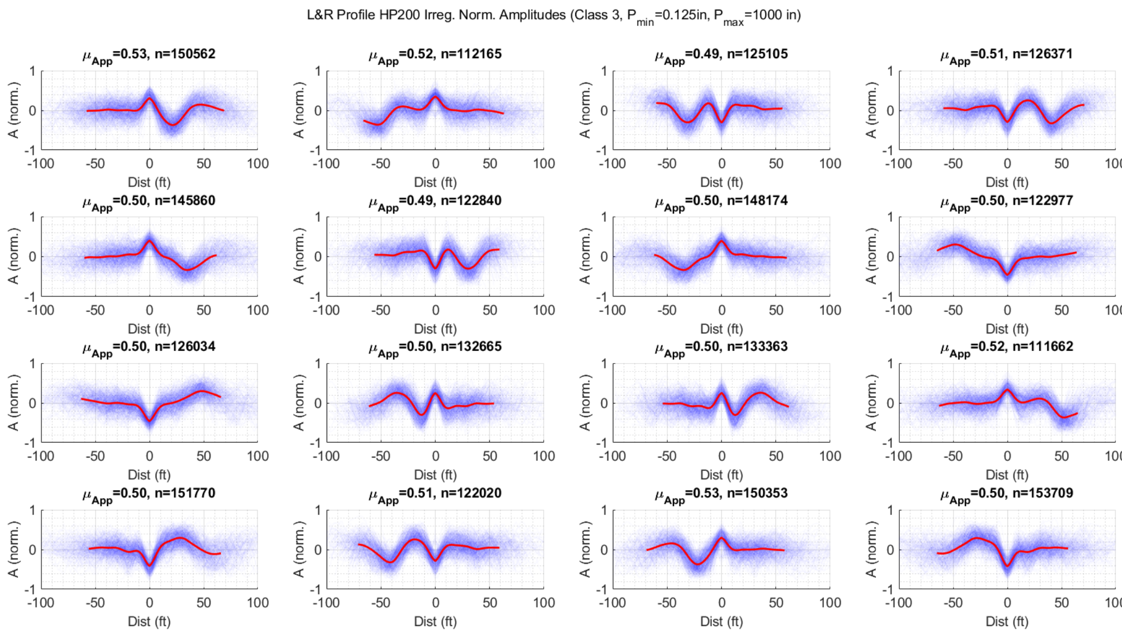


Figure 45. Vertical track irregularities separated into 16 clusters

Figure 46 shows a clustering plot with actual (i.e., non-normalized) amplitudes of irregularities. Mean, as well as the upper and lower 2.5th percentiles of track geometry variable within cluster as functions distance from irregularity apex are shown.

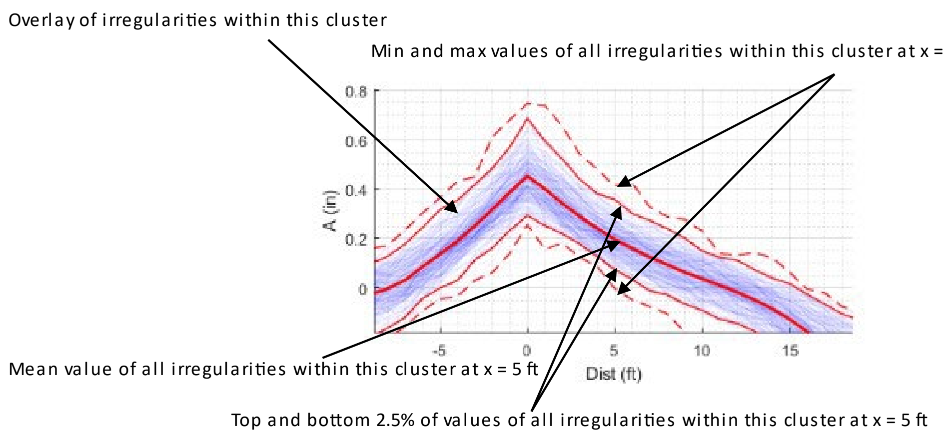
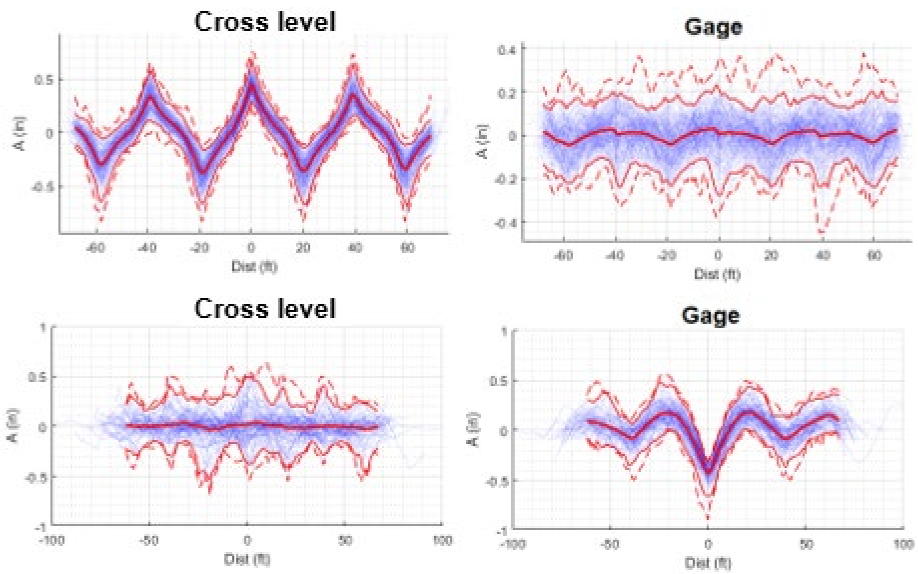


Figure 46. Statistical description of track irregularities within a cluster

This clustering method also allows for the performance of a qualitative analysis of the relationship between two track geometry variables. The process is as follows:

1. First variable (i.e., cross level) is used to find the locations of track irregularities. For example, an apex of a cross level irregularity is located at x=1,200 feet. Cross level values between x=1,000 and x=1,400 feet are saved as irregularity No. 35.
2. The values of the second variable (i.e., gage) in the same location (values between x=1,000 and x=1,400 feet) are recorded as well.

3. All irregularities of the first variable are then clustered by shape. For example, cross level irregularities Nos. 35, 36, 78, and 135 are found to have approximately the same triangular shape and are thus grouped in cluster No. 1. Gage irregularities at the same locations are grouped into one cluster regardless of the irregularity shapes and are plotted side-by-side with the cluster of cross level irregularities.
4. Examination of clustered cross level irregularities side-by-side with gage irregularities shows that in locations with triangular-shaped cross level irregularities, the gage has a slight tendency to exhibit cusp-shaped irregularities (Figure 47, top row).
5. Similarly, if gage irregularities are clustered by shape and shown side-by-side with cross level irregularities in the same location, a weak correlation may be seen (Figure 47, bottom row).
6. 

top row: cross level shape used for clustering; bottom row: gage shape used for clustering

Figure 47. Example of analysis of correlation between cross level (left) and gage (right) irregularities within the same cluster

The clustering algorithm used for this study was built to analyze the correlations between various TG variables, including the space curve. Therefore, it only analyzed track sections for which space curve data was available, significantly limiting the mileage available for lower track classes (2 miles for Class 1 track and 28 miles of Class 2 track). For this reason, this report omits clustering analysis for Class 1 track, and the clustering results for Class 2 track should be viewed with caution.

Note that the k-means++ clustering algorithm used here is non-deterministic, i.e., using this algorithm several times will give slightly different results each time. Nevertheless, experiments with this dataset show that the irregularity shapes identified with this method remain consistent.

7.2 Results

Appendix D shows the clustering plots of gage, cross level, alignment, and surface (i.e., profile) space curve.

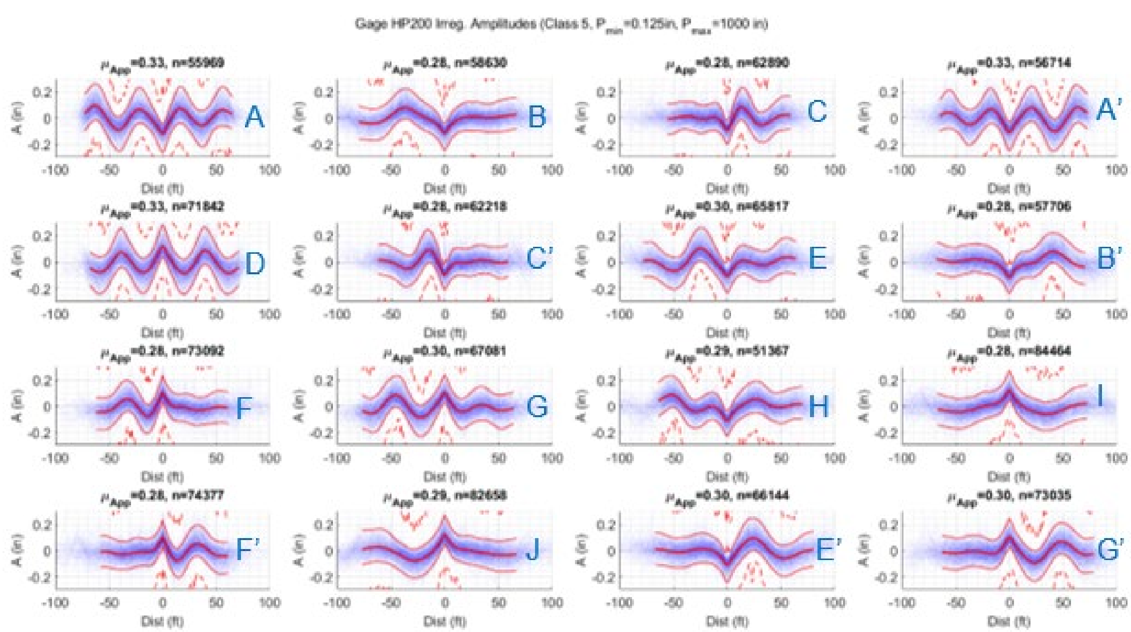
Each figure in the appendix was generated using the following settings:

- TG data was separated by FRA track class.
- Prior to the clustering analysis, the TG variable was filtered with a second order high-pass Butterworth filter with a cutoff wavelength of 200 feet (indicated by "HP200" in the plot headers), cascaded in forward and in reverse to eliminate phase distortion.
- Very small track irregularities were ignored. Only irregularities with peak prominence greater than 0.125 inch were analyzed.
- Irregularities were grouped into 16 shapes (i.e., clusters) using k-means++ clustering. Experiments performed using this data set have shown that further increasing the number of clusters results in too many repetitive shapes with only minor differences between them.

Each figure has 16 subplots, one for each common irregularity shape. Since the same type of irregularity will appear "mirrored" when traversed in the opposite direction, many of these shapes are mirror images of each other. The number above the subplot indicates the number of irregularities in the cluster. Translucent blue lines indicate individual irregularities, the thick red line denotes the averaged irregularity shape, thin red lines represent the 2.5th and 97.5th percentiles of irregularities in that cluster, and dashed lines depict the minimum and maximum irregularities.

The sign convention for clustering plots is similar to one for bivariate tables (i.e., outward and upward deviations are positive).

Figure 48 shows an example of clustering results. Over 1 million gage irregularities found in Class 5 track are clustered into 16 shapes with mean peak-to-peak amplitudes between 0.28 and 0.33 inch.



Blue letters next to shapes are used to identify shapes that mirror each other left-to-right

Figure 48. Example of clustering analysis of gage irregularities on Class 5 track

Figure 49 shows the histograms of these amplitudes; note that the modes of amplitudes (about 0.23 inch) are significantly lower than the mean values.

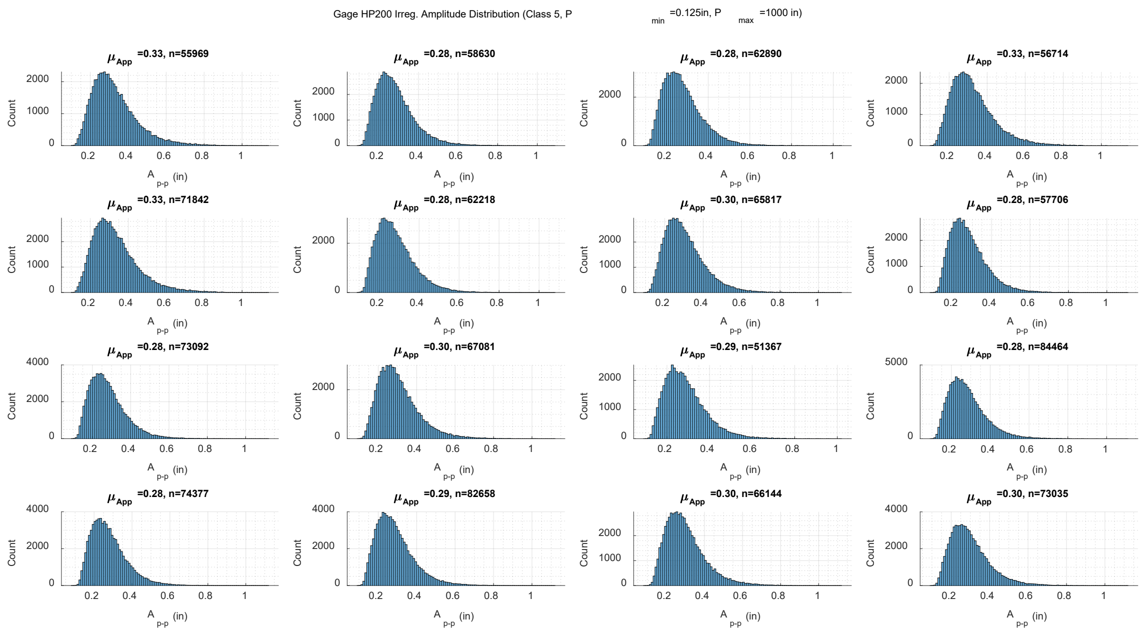


Figure 49. Histogram of peak-to-peak amplitudes of gage irregularities from Figure 48

Gage irregularities tend to have a shape of a cusp, inverted cusp, a sharp dip, a bump, or a combination of these. Cusps are typically about 40 feet long (presumably associated with rail joints), and sharp dips that are not part of cusps are about 20 feet long. Longer (i.e., 50- to 60-foot-long) cusps and sine waves are observed as well. Multiple cusps are often observed back-to-back. All these waveforms are observable in both lower and higher classes of track, although multiple back-to-back cusps were mainly encountered in Class 5 track. Mean peak-to-peak amplitudes of 40-foot cusps vary from 0.19-0.21 inch (Class 8 track) to 0.31-0.34 inch (Class 3 track).

Cross level irregularities (Figure 50) consist of cusps that are often about 40 feet long but occasionally are shorter (20~30 feet) or longer (60~70 feet). Mean amplitudes of 40-foot cusps vary from 0.21~0.25 inch (Class 8) to 0.34 inch (Class 3). Additionally, 40-foot triangular waves, a consequence of staggered rail joints, are present in Class 3 track. The mean amplitude of these waves is much higher, 0.44~0.46 inch.

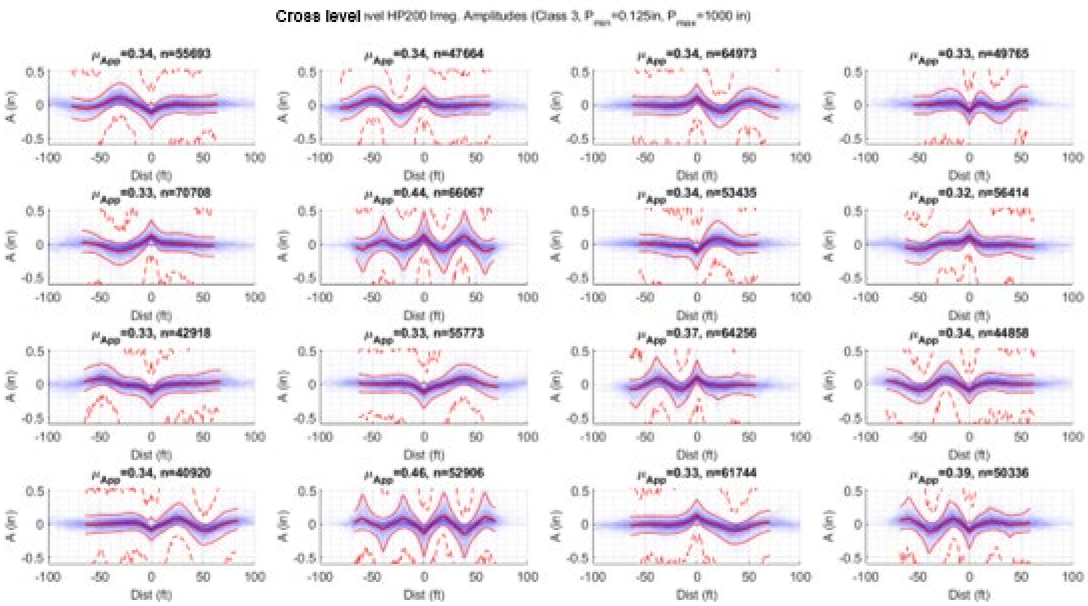


Figure 50. Cross level irregularities on Class 3 track

Alignment irregularities (Figure 51) also include cusps and inverted cusps approximately 40 and 80 feet long, lengths that are consistent with the 39-foot and 80-foot peaks seen on the PSD plots (Section 6.2). Mean amplitudes of alignment irregularities vary from 0.19~0.22 inch (Class 8 track) to 0.30~0.36 inch (Class 3 track).

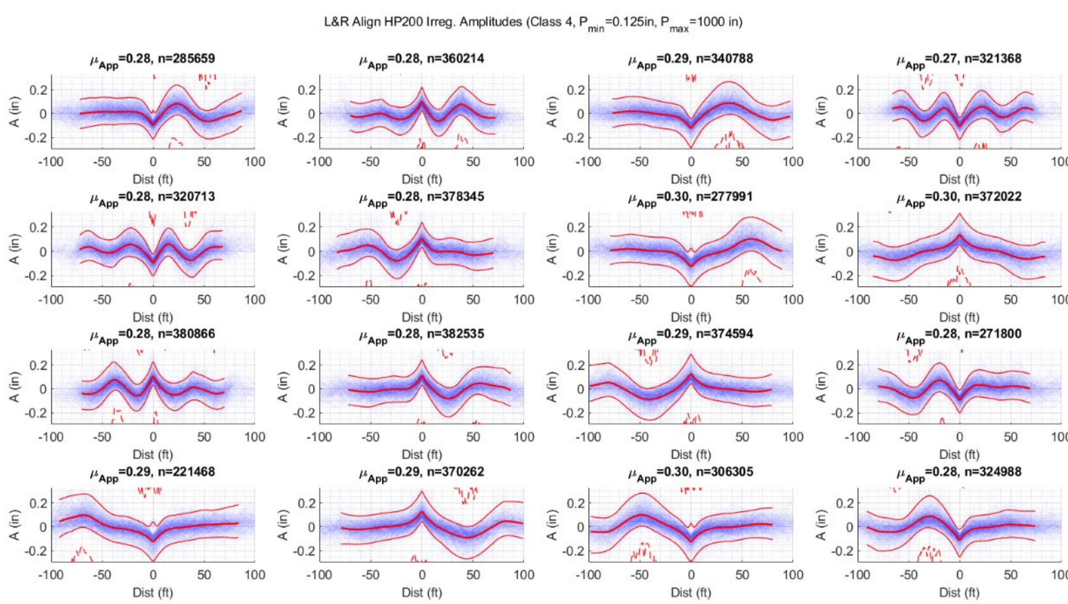


Figure 51. L&R rail alignment irregularities on Class 4 track

Unsurprisingly, cusps about 40 feet long appear among surface irregularities as well (Figure 52). Interestingly, shapes that can be described as "inverted cusps" of similar length can also be observed among surface irregularities. For higher track classes (6–8), cusp-shaped surface irregularities become less common. Shorter and smoother irregularities appear instead, some of them resembling the deterministic shapes proposed in the 1980s, including "jog," "bump," "sinusoid," and various combinations of these (Hamid et al., 1983b). Unlike with alignment variables, 80-foot-long cusps do not appear to be common, again consistent with the PSD plots. Mean peak-to-peak amplitudes of surface irregularities vary from 0.25~0.35 inch (Class 8 track) to 0.48~0.53 inch (Class 3 track).

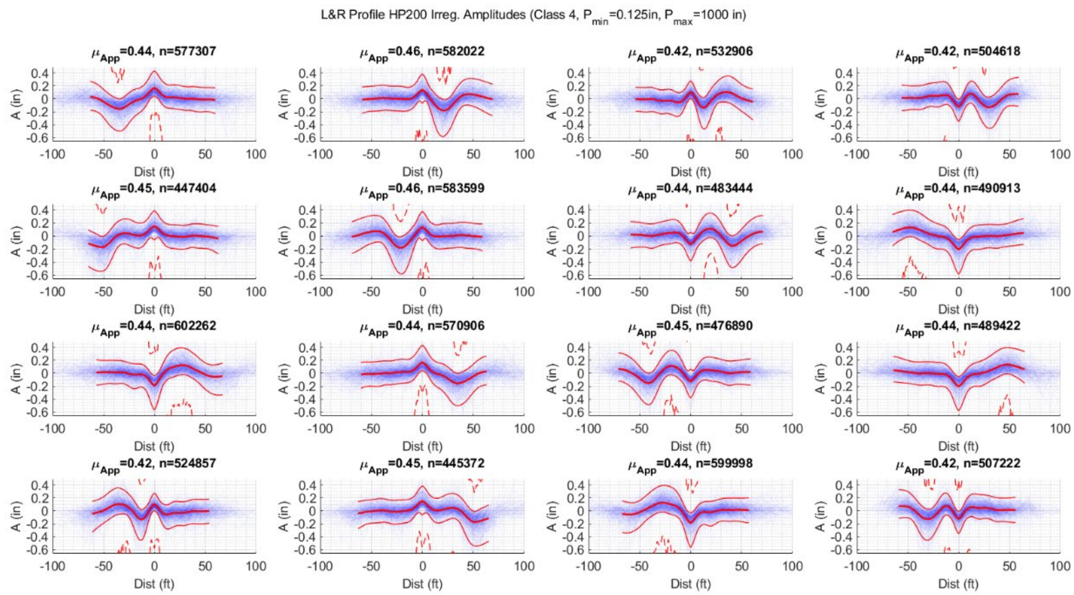


Figure 52. L&R rail surface irregularities on Class 4 track

When examining the mean amplitudes of various irregularity clusters, it is important to remember that only local minima and maxima with peak prominences of over 0.125 inch were considered for clustering analysis.

No strong dependencies between irregularity shapes and their mean amplitudes were observed, except with multiple back-to-back gage and cross level irregularities. Such harmonic irregularities tended to have higher amplitudes (see Figure 48 and Figure 50).

When irregularities on curved track only were clustered separately (Figure 53), their shapes did not differ substantially from other irregularities on the same track class (Figure 45). Likewise, when the clustering analysis was limited to large irregularities only (Figure 54), the shapes of the large irregularities were not out of the ordinary for the given track class. Furthermore, separating irregularities by size or by track curvature failed to demonstrate a correlation between vertical and lateral irregularities, aside from a weak correlation like the one shown in Figure 47. Figure 55 shows several clusters of large vertical irregularities (Class 3 track, curved track only; minimum peak prominence 0.75 inch) and the lateral irregularities corresponding to each cluster. The correlation between the vertical and lateral irregularities remains very weak. An attempt was made to further narrow down this analysis to the high rail in curves, but some difficulties were encountered when merging the TG data from different track segments. Further analysis could be performed to verify whether the correlation between vertical and lateral irregularities in high rail in curves is any stronger than in other sections of the track.

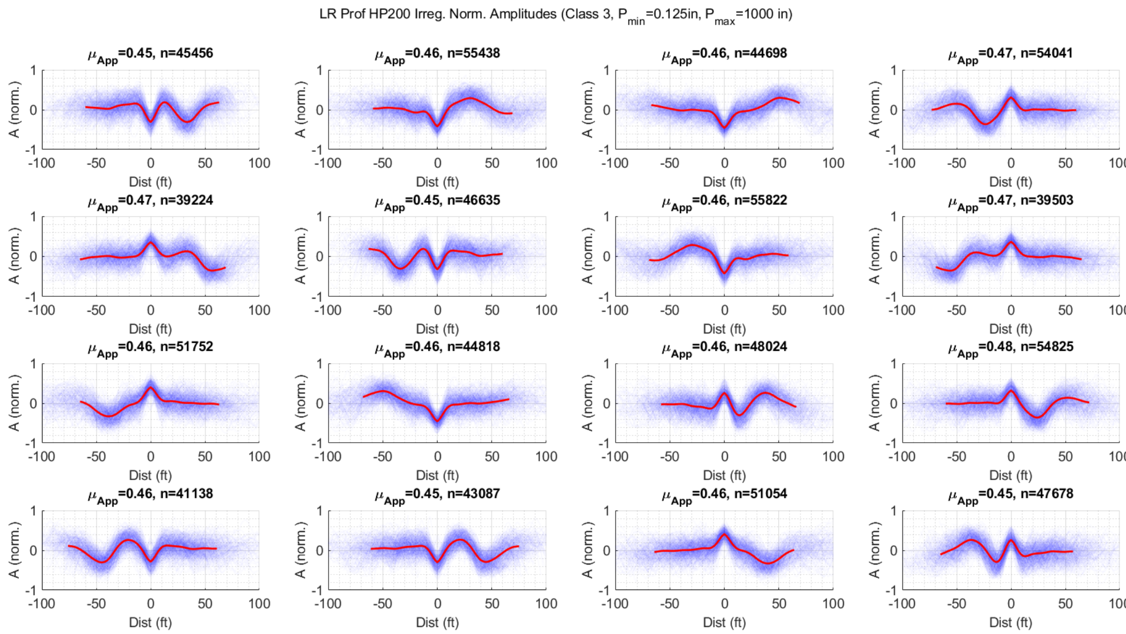


Figure 53. Vertical irregularities on Class 3 curved track

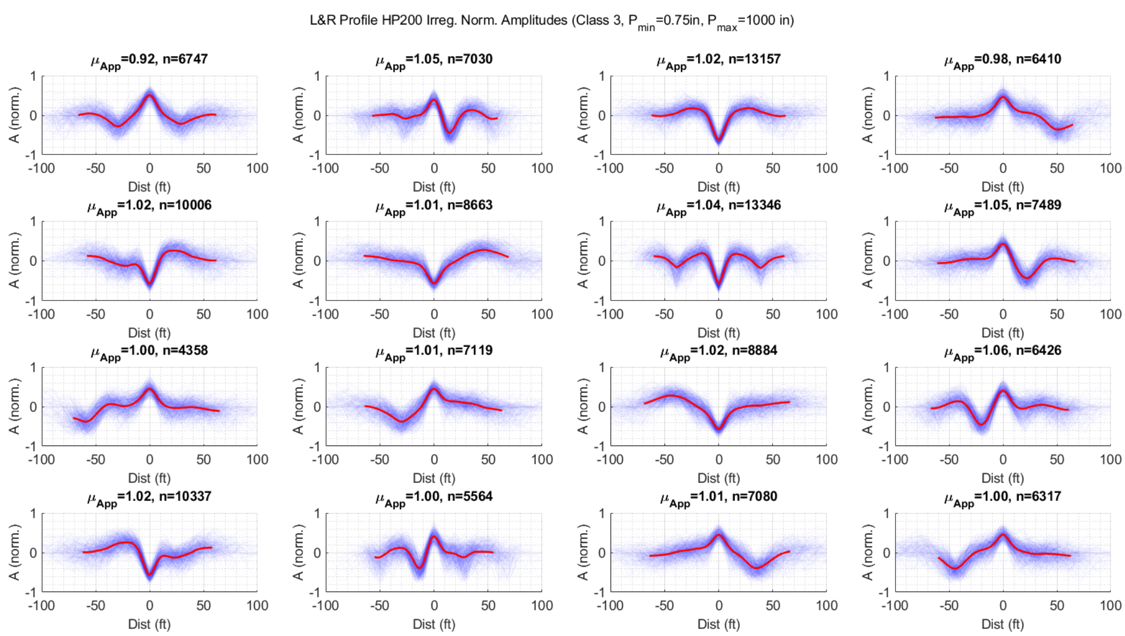
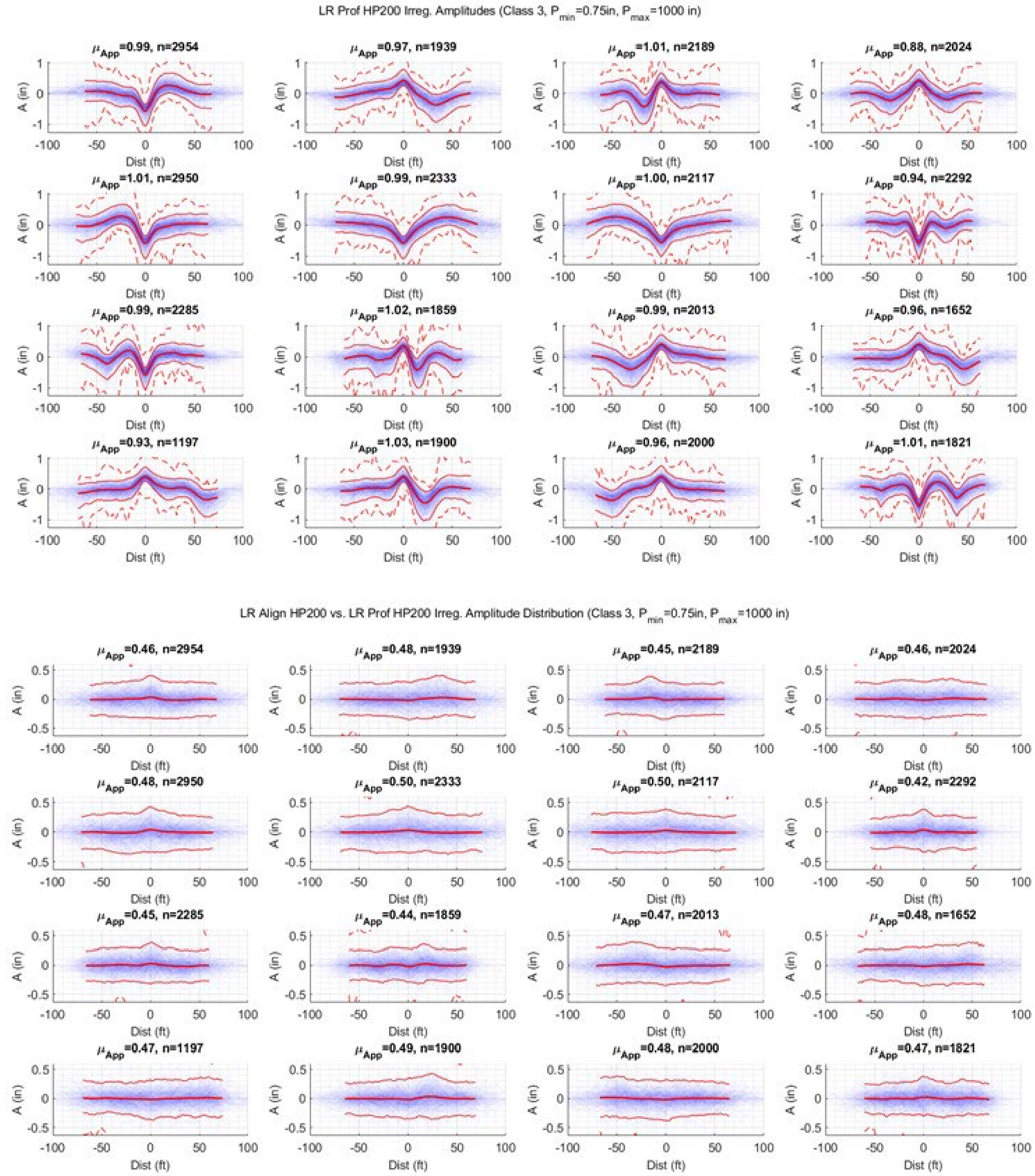


Figure 54. Vertical irregularities with minimum prominence of 0.75 inch on Class 3 track



Analysis is narrowed down to large vertical irregularities on curved Class 3 track

top 4 rows: clustered vertical irregularities; bottom 4 rows: lateral irregularities corresponding to the clusters above

Figure 55. Clustering analysis of correlation between vertical and lateral irregularities

8. Summary and Conclusions

The primary objectives of the study were to characterize the amplitude and wavelength content of the current track geometry environment of the United States railroad system and examine the combination of geometry parameters for different operations. These objectives were achieved by analyzing track geometry data from over 49,000 miles of track, measured between 2012 and 2019. The types of characterization included statistical, frequency-based, and clustering characterization.

An assessment of the waveforms obtained by the clustering analysis showed that the irregularity waveforms are complex and cannot accurately be represented by amplitude and wavelength alone. Frequency-based methods capture both amplitude and wavelength content, though these methods make the interpretation of the waveforms present in track geometry measurements more difficult. The clustering analysis presented the best characterization of the track geometry waveforms and amplitudes.

The results showed that the following observations are significant for United States railroads when considering track geometry:

- Compared to other parameters (e.g., route traffic type, tie type, curvature, etc.), FRA track class has the most influence on the overall quality of track geometry.
- All TG variable values are more severe on track with wooden ties than on track with concrete ties, suggesting that maintaining track with concrete ties within a given track class may be easier than track with wood ties.
- Gage and alignment values tend to be more severe on curved track than on tangent track, likely due to curving forces and rail gage face wear.
- Surface irregularity values tend to be less severe on curved track.
- Additionally, cross level and surface values are more severe on freight-only routes than on primarily passenger routes.

The following conclusions were drawn from the various analyses discussed in the report:

- The four principal TG variables (i.e., gage, cross level, mean alignment, and mean surface) are largely independent.
- Likewise, alignment and surface irregularities within the same rail are not strongly correlated and can be considered largely independent of each other. However, there is a weak correlation between certain lateral and vertical track irregularities that can be attributed to rail length.
- Severe instances where both alignment and surface irregularities exceed the allowable 49 CFR 213 limits are very rare and usually occur with a frequency of 0.02 foot/mile of rail or less.
- Clustering analysis reveals the typical waveform shapes and amplitudes of track irregularities.
- The waveforms identified by the clustering analysis could be further developed to use as representative track input for vehicle-track interaction simulation models. Further

analyses may be required to determine whether these waveforms would provide a more appropriate description of representative track perturbation shapes than the hypothetical shapes developed in previous research (Hamid et al., 1983b).

The comparison of TG data from the 2010s with the data from the 1970s showed mixed results. Because the total mileage of data from the 1970s (150 miles) is much less than the amount of data from the 2010s (over 49,000 miles), and the exact locations of the measurements taken in the 1970s are not known, it was not possible to determine from these data whether overall track quality in the 2010s has significantly changed compared with the track quality of the 1970s. However, the following general observations can be made:

- Irregularities associated with 39-foot rails are prominent in data from both the 1970s and the 2010s.
- The gage and alignment data from the 2010s also show irregularities consistent with 80-foot rail lengths that were not observed in the 1970s.
- The overall severity of track gage is similar between the old and the new data.
- Mean alignment values seem to be less severe in the new data than in the old data.
- Mean surface and cross level values are inconsistent, with results varying depending on measuring device and location.

Frequency-based methods may be more applicable for:

- The assessment of the improvement or deterioration of a section of track by comparing the results from various measurement campaigns over time
- The determination of the rate of deterioration of a section of track and assistance with maintenance planning and prioritization

The bivariate statistical tables and clustering analysis discussed in this report facilitate future research in the assessment of track geometry:

- The single-variable and bivariate statistical tables in this report can be used to estimate the likelihood of encountering alignment and surface irregularities or combinations of the two of any given magnitude in various FRA track classes.
- The typical irregularity shapes identified by means of clustering represent shapes of defect with scalable amplitude that could be used in further track geometry studies to determine the shapes most detrimental to the vehicle-track system's safety.
- A combination of the bivariate statistical tables and clustering analysis can be used to construct artificial combined track geometries for further study and as an input for vehicle-track interaction simulation models.
- The bivariate analysis methods developed could be useful for planning and prioritizing track maintenance work to target track locations with the worst-case combinations of irregularities.

The outputs of the analysis included in this report demonstrate some of the capabilities of the computer programs (i.e., MATLAB scripts) and data analysis algorithms developed throughout this study. These MATLAB scripts and analysis algorithms are available for use in future studies.

These software tools and data analysis methods may be useful to railroad maintenance personnel for the purpose of track geometry measurements analysis. This analysis will allow maintenance personnel to do the following:

- Identify worst-case combinations of track irregularities
- Evaluate track irregularity shapes to identify common track features that may generate the shapes
- Prioritize and plan maintenance work to target worst-case conditions

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Appendix A.
Single Variable Statistical Tables

This appendix contains the statistical tables described in Section 5.1.

Gage

Table 1. Gage statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	725.8	55.622	56.024	56.382	56.528	56.697	57.398	58.202	56.557	56.492	0.272	0.315	0.822	4.569
2	3,240.5	55.757	56.127	56.438	56.563	56.721	57.288	57.878	56.595	56.492	0.235	0.282	0.747	4.033
3	9,731.3	55.851	56.189	56.457	56.575	56.717	57.217	57.780	56.600	56.492	0.211	0.260	0.719	3.991
4	27,692.3	55.890	56.209	56.445	56.555	56.673	57.052	57.532	56.569	56.492	0.176	0.228	0.507	3.571
5	7,655.1	55.926	56.217	56.406	56.492	56.599	56.937	57.372	56.510	56.453	0.150	0.193	0.633	3.747
6	152.2	55.970	56.337	56.506	56.573	56.663	56.910	57.404	56.588	56.532	0.120	0.157	0.465	3.704
7	228.0	55.950	56.369	56.529	56.605	56.697	56.930	57.298	56.616	56.536	0.121	0.168	0.357	3.215
8	185.3	55.980	56.376	56.524	56.590	56.648	56.897	57.204	56.592	56.593	0.103	0.123	0.494	4.409

Table 2. Gage statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	430.5	55.623	56.003	56.343	56.481	56.619	57.028	57.862	56.484	56.492	0.215	0.276	0.211	3.536
	Curved	295.2	55.615	56.072	56.449	56.618	56.835	57.544	58.255	56.663	56.532	0.310	0.386	0.711	3.669
2	Tang.	1,837.0	55.762	56.099	56.398	56.508	56.626	56.988	57.628	56.515	56.492	0.181	0.228	0.264	3.687
	Curved	1,403.5	55.745	56.209	56.512	56.662	56.858	57.382	57.937	56.698	56.532	0.257	0.346	0.570	3.211
3	Tang.	5,747.9	55.859	56.166	56.422	56.524	56.634	56.969	57.504	56.532	56.492	0.166	0.212	0.328	3.633
	Curved	3,983.4	55.831	56.252	56.532	56.673	56.839	57.315	57.858	56.698	56.571	0.230	0.307	0.530	3.286
4	Tang.	20,961.2	55.886	56.201	56.433	56.532	56.642	56.969	57.413	56.543	56.492	0.161	0.209	0.372	3.437
	Curved	6,731.0	55.923	56.256	56.508	56.634	56.775	57.158	57.658	56.649	56.571	0.196	0.266	0.407	3.122
5	Tang.	6,345.5	55.930	56.213	56.398	56.477	56.571	56.878	57.272	56.491	56.453	0.138	0.173	0.558	3.740
	Curved	1,309.7	55.894	56.260	56.485	56.595	56.713	57.044	57.441	56.605	56.571	0.170	0.228	0.369	3.136
6	Tang.	93.3	55.946	56.316	56.499	56.565	56.658	56.859	57.203	56.579	56.532	0.116	0.159	0.233	3.324
	Curved	58.9	56.018	56.371	56.519	56.585	56.672	56.955	57.546	56.604	56.555	0.124	0.154	0.739	3.897
7	Tang.	150.2	55.930	56.356	56.518	56.590	56.676	56.847	57.351	56.597	56.536	0.111	0.158	0.130	3.083
	Curved	77.8	56.113	56.413	56.554	56.639	56.741	56.979	57.221	56.654	56.566	0.130	0.187	0.426	2.777
8	Tang.	157.9	55.975	56.370	56.514	56.580	56.634	56.798	57.215	56.577	56.593	0.091	0.120	0.053	3.502
	Curved	27.4	56.323	56.438	56.596	56.655	56.743	57.009	57.204	56.677	56.635	0.120	0.147	0.710	3.563

Table 3. Gage statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	30.7	55.742	56.178	56.508	56.650	56.803	57.457	58.276	56.674	56.650	0.251	0.295	0.865	5.009
	Midwest	132.3	55.623	56.079	56.414	56.551	56.713	57.402	58.140	56.583	56.532	0.260	0.299	0.908	4.769
	South	331.5	55.612	56.032	56.386	56.532	56.697	57.370	58.158	56.559	56.492	0.267	0.311	0.751	4.314
	West	230.1	55.637	55.985	56.343	56.492	56.658	57.429	58.251	56.523	56.492	0.284	0.315	0.967	4.951
	Unk.	1.1													
2	Northeast	151.4	55.776	56.264	56.544	56.681	56.854	57.437	58.015	56.717	56.611	0.246	0.310	0.782	3.873
	Midwest	723.7	55.858	56.170	56.438	56.559	56.693	57.189	57.772	56.578	56.532	0.206	0.256	0.683	4.100
	South	977.9	55.721	56.131	56.442	56.579	56.736	57.288	57.878	56.604	56.492	0.238	0.294	0.657	3.836
	West	1,379.2	55.757	56.103	56.429	56.541	56.705	57.299	57.806	56.583	56.492	0.243	0.276	0.804	4.044
	Unk.	8.2													
3	Northeast	1,139.1	55.864	56.309	56.554	56.665	56.807	57.323	57.870	56.697	56.611	0.211	0.253	0.842	4.024
	Midwest	2,053.7	55.891	56.181	56.434	56.548	56.689	57.174	57.752	56.574	56.492	0.205	0.255	0.740	4.072
	South	3,274.4	55.867	56.205	56.472	56.583	56.713	57.205	57.772	56.606	56.532	0.202	0.241	0.738	4.188
	West	3,219.9	55.820	56.162	56.433	56.547	56.693	57.190	57.756	56.577	56.492	0.213	0.260	0.717	3.835
	Unk.	44.1	55.759	56.249	56.465	56.575	56.703	57.162	57.539	56.597	56.492	0.188	0.238	0.764	4.064
4	Northeast	1,198.0	56.016	56.331	56.536	56.638	56.756	57.138	57.609	56.655	56.571	0.167	0.220	0.651	3.802
	Midwest	6,606.5	55.918	56.232	56.437	56.536	56.647	57.020	57.539	56.552	56.492	0.163	0.210	0.629	3.893
	South	9,844.6	55.902	56.233	56.492	56.603	56.724	57.091	57.548	56.613	56.532	0.180	0.232	0.376	3.372
	West	9,748.3	55.871	56.178	56.414	56.512	56.623	56.998	57.465	56.528	56.492	0.168	0.209	0.549	3.804
	Unk.	295.0	55.855	56.186	56.386	56.473	56.583	56.925	57.850	56.493	56.414	0.150	0.197	0.735	4.428
5	Northeast	65.9	55.971	56.373	56.509	56.569	56.641	56.924	57.371	56.583	56.560	0.112	0.133	0.908	5.138
	Midwest	1,686.8	55.981	56.250	56.410	56.489	56.603	56.972	57.366	56.518	56.453	0.154	0.193	0.870	3.910
	South	346.7	55.984	56.221	56.418	56.496	56.599	56.874	57.307	56.513	56.492	0.140	0.181	0.503	3.582
	West	5,340.7	55.910	56.209	56.402	56.489	56.591	56.918	57.374	56.503	56.492	0.148	0.189	0.573	3.728
	Unk.	214.9	56.012	56.315	56.512	56.607	56.713	57.008	57.414	56.619	56.532	0.150	0.200	0.418	3.213
6	Northeast	116.7	55.951	56.363	56.505	56.574	56.668	56.900	57.460	56.590	56.533	0.118	0.163	0.517	3.442
	Midwest	2.2													
	South	28.1	56.089	56.394	56.528	56.582	56.655	56.930	57.209	56.599	56.532	0.106	0.127	0.854	4.800
	West	5.2													
	Unk.	0.0													
7	Northeast	96.3	55.895	56.346	56.491	56.555	56.640	56.844	57.335	56.568	56.535	0.109	0.149	0.416	3.271
	Midwest	0.0													
	South	131.6	56.073	56.427	56.565	56.644	56.726	56.957	57.264	56.652	56.586	0.116	0.161	0.400	3.216
	West	0.2													
	Unk.	0.0													
8	Northeast	136.4	55.972	56.366	56.502	56.564	56.613	56.773	57.094	56.558	56.593	0.083	0.111	0.039	4.035
	Midwest	0.0													
	South	48.9	56.051	56.496	56.622	56.674	56.732	56.980	57.489	56.684	56.669	0.095	0.110	0.809	4.936
	West	0.0													
	Unk.	0.0													

Table 4. Gage statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	666.5	55.615	56.020	56.382	56.532	56.701	57.406	58.197	56.559	56.492	0.274	0.319	0.803	4.531
	Concrete	27.1	55.751	56.067	56.370	56.465	56.603	57.303	58.371	56.508	56.414	0.236	0.232	1.277	6.219
	Unk.	32.2	55.667	56.038	56.372	56.512	56.675	57.348	57.966	56.546	56.496	0.265	0.302	0.873	4.455
2	Timber	2,486.9	55.745	56.114	56.437	56.567	56.721	57.284	57.874	56.593	56.492	0.237	0.283	0.672	3.961
	Concrete	556.8	55.973	56.233	56.449	56.543	56.717	57.296	57.735	56.600	56.492	0.225	0.268	1.083	4.241
	Unk.	196.8	55.815	56.138	56.438	56.556	56.713	57.310	57.987	56.594	56.492	0.238	0.275	0.886	4.304
3	Timber	7,334.0	55.855	56.185	56.465	56.583	56.720	57.217	57.804	56.605	56.532	0.210	0.255	0.683	4.046
	Concrete	1,316.7	55.879	56.221	56.443	56.543	56.693	57.186	57.705	56.583	56.492	0.205	0.250	0.893	4.006
	Unk.	1,080.6	55.802	56.179	56.436	56.556	56.713	57.233	57.714	56.591	56.492	0.224	0.276	0.768	3.728
4	Timber	20,261.4	55.886	56.205	56.461	56.567	56.685	57.060	57.532	56.581	56.532	0.176	0.224	0.442	3.576
	Concrete	4,275.8	55.962	56.219	56.394	56.486	56.607	57.004	57.442	56.513	56.453	0.165	0.213	0.846	4.018
	Unk.	3,155.1	55.894	56.213	56.446	56.553	56.673	57.060	57.592	56.568	56.492	0.175	0.227	0.556	3.724
5	Timber	5,817.0	55.922	56.213	56.418	56.512	56.615	56.945	57.378	56.523	56.492	0.153	0.197	0.523	3.628
	Concrete	1,123.5	55.993	56.244	56.378	56.437	56.496	56.807	57.315	56.449	56.414	0.110	0.118	1.160	6.262
	Unk.	714.7	55.903	56.202	56.384	56.485	56.602	56.945	57.361	56.503	56.492	0.161	0.219	0.613	3.356
6	Timber	6.1													
	Concrete	1.9													
	Unk.	144.3	55.963	56.366	56.509	56.575	56.664	56.903	57.425	56.591	56.537	0.115	0.155	0.549	3.602
7	Timber	0.3													
	Concrete	0.0													
	Unk.	227.7	55.950	56.369	56.529	56.605	56.696	56.925	57.298	56.616	56.536	0.120	0.167	0.341	3.177
8	Timber	0.0													
	Concrete	0.0													
	Unk.	185.3	55.980	56.376	56.524	56.590	56.648	56.897	57.204	56.592	56.593	0.103	0.123	0.494	4.409

Table 5. Gage statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	526.1	55.600	56.020	56.375	56.524	56.689	57.394	58.162	56.550	56.492	0.270	0.315	0.822	4.683
	Prim. Frgt.	189.8	55.658	56.032	56.391	56.536	56.717	57.409	58.250	56.574	56.492	0.278	0.327	0.815	4.263
	Prim. Pass.	9.8													
2	Frgt. Only	2,160.4	55.752	56.107	56.422	56.551	56.709	57.276	57.890	56.580	56.492	0.237	0.287	0.698	3.954
	Prim. Frgt.	984.5	55.771	56.197	56.473	56.579	56.737	57.308	57.839	56.621	56.492	0.228	0.264	0.920	4.251
	Prim. Pass.	95.6	55.849	56.221	56.485	56.601	56.775	57.315	57.758	56.647	56.492	0.233	0.290	0.820	3.665
3	Frgt. Only	5,270.0	55.847	56.166	56.438	56.552	56.689	57.189	57.772	56.577	56.492	0.207	0.252	0.730	4.188
	Prim. Frgt.	3,806.2	55.859	56.225	56.481	56.603	56.748	57.243	57.803	56.629	56.492	0.213	0.267	0.713	3.797
	Prim. Pass.	655.0	55.864	56.229	56.479	56.591	56.729	57.221	57.756	56.620	56.492	0.206	0.250	0.775	3.917
4	Frgt. Only	12,395.6	55.879	56.186	56.434	56.540	56.650	57.024	57.504	56.550	56.492	0.171	0.216	0.471	3.783
	Prim. Frgt.	14,497.1	55.914	56.233	56.457	56.571	56.697	57.071	57.547	56.587	56.532	0.180	0.240	0.505	3.347
	Prim. Pass.	799.5	55.804	56.201	56.437	56.524	56.619	57.020	57.563	56.537	56.492	0.158	0.181	0.724	4.850
5	Frgt. Only	2,608.3	55.957	56.245	56.406	56.485	56.587	56.902	57.315	56.504	56.453	0.140	0.181	0.698	3.760
	Prim. Frgt.	4,770.1	55.922	56.205	56.406	56.496	56.607	56.953	57.382	56.515	56.492	0.157	0.201	0.585	3.631
	Prim. Pass.	276.7	55.867	56.233	56.418	56.489	56.568	56.839	57.425	56.498	56.453	0.123	0.150	0.583	4.956
6	Frgt. Only	1.7													
	Prim. Frgt.	5.3													
	Prim. Pass.	145.3	55.964	56.365	56.508	56.574	56.664	56.903	57.423	56.590	56.532	0.116	0.155	0.548	3.591
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	227.6	55.991	56.371	56.529	56.605	56.696	56.925	57.299	56.616	56.536	0.120	0.167	0.357	3.144
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	185.3	55.980	56.376	56.524	56.590	56.648	56.897	57.204	56.592	56.593	0.103	0.123	0.494	4.409

Cross level (Unfiltered)

Table 6. Cross level (unfiltered) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	725.8	-5.163	-2.063	-0.302	-0.001	0.295	1.952	4.904	-0.005	0.000	0.705	0.597	-0.117	7.618
2	3,240.5	-7.920	-3.270	-0.266	0.022	0.314	3.225	6.199	0.018	0.000	1.040	0.580	-0.121	7.301
3	9,731.3	-6.193	-3.849	-0.226	0.024	0.277	3.934	6.451	0.022	0.000	1.248	0.503	0.016	6.794
4	27,692.3	-6.005	-4.061	-0.140	0.016	0.172	4.114	6.133	0.016	0.000	1.132	0.312	0.024	10.037
5	7,655.1	-5.950	-3.628	-0.104	0.020	0.145	3.860	6.244	0.025	0.000	0.987	0.249	0.149	12.770
6	152.2	-6.545	-5.619	-0.078	0.055	0.205	6.002	6.906	0.094	0.000	2.105	0.283	0.111	5.016
7	228.0	-6.752	-5.415	-0.072	0.061	0.195	5.724	6.643	0.040	0.000	2.028	0.267	0.072	5.416
8	185.3	-6.258	-5.267	-0.018	0.054	0.127	5.696	6.809	0.075	0.000	1.268	0.145	0.306	15.010

Table 7. Cross level (unfiltered) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	430.5	-2.790	-1.152	-0.225	-0.006	0.209	1.132	2.897	-0.010	0.000	0.413	0.433	-0.006	5.827
	Curved	295.2	-5.485	-2.611	-0.551	0.015	0.576	2.469	5.004	0.003	0.000	0.987	1.127	-0.123	4.628
2	Tang.	1,837.0	-2.191	-0.796	-0.132	0.022	0.175	0.833	2.257	0.021	0.000	0.295	0.306	0.003	6.169
	Curved	1,403.5	-8.035	-3.788	-0.920	0.029	0.961	3.684	6.431	0.013	0.000	1.544	1.881	-0.076	3.460
3	Tang.	5,747.9	-1.799	-0.625	-0.103	0.026	0.154	0.702	1.815	0.027	0.000	0.242	0.256	0.054	6.050
	Curved	3,983.4	-6.313	-4.310	-1.176	0.017	1.188	4.413	6.562	0.015	0.000	1.928	2.363	0.021	2.907
4	Tang.	20,961.2	-1.696	-0.533	-0.095	0.016	0.127	0.571	1.681	0.016	0.000	0.204	0.222	0.051	6.333
	Curved	6,731.0	-6.101	-4.786	-1.416	0.006	1.460	4.861	6.459	0.016	-0.923	2.268	2.876	0.012	2.563
5	Tang.	6,345.5	-1.268	-0.448	-0.078	0.021	0.120	0.485	1.256	0.021	0.000	0.176	0.198	-0.023	5.768
	Curved	1,309.7	-6.360	-4.789	-1.653	-0.011	1.715	4.877	6.597	0.043	-0.962	2.353	3.368	0.041	2.303
6	Tang.	93.3	-1.224	-0.343	-0.013	0.052	0.122	0.526	1.562	0.056	0.000	0.152	0.135	0.340	13.002
	Curved	58.9	-6.558	-5.894	-2.593	0.146	2.848	6.224	7.003	0.155	0.000	3.378	5.441	0.016	1.952
7	Tang.	150.2	-1.254	-0.280	-0.013	0.062	0.140	0.448	1.607	0.065	0.000	0.139	0.154	0.260	9.156
	Curved	77.8	-6.776	-5.997	-2.799	0.012	2.780	6.112	6.676	-0.007	-4.980	3.465	5.579	0.083	1.865
8	Tang.	157.9	-1.138	-0.211	-0.006	0.052	0.114	0.403	1.424	0.056	0.000	0.122	0.120	0.329	22.117
	Curved	27.4	-6.385	-5.898	-2.332	0.095	2.715	6.650	6.824	0.184	0.466	3.283	5.046	0.020	2.252

Table 8. Cross level (unfiltered) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	30.7	-3.789	-2.399	-0.236	-0.013	0.204	2.511	3.575	-0.023	-0.038	0.717	0.439	-0.040	9.283
	Midwest	132.3	-3.790	-1.896	-0.284	0.017	0.308	1.783	3.661	0.010	0.000	0.636	0.592	-0.219	6.335
	South	331.5	-5.426	-2.085	-0.348	-0.028	0.289	1.888	4.202	-0.032	0.000	0.710	0.637	-0.166	6.074
	West	230.1	-5.144	-2.095	-0.258	0.023	0.309	2.061	5.034	0.028	0.000	0.734	0.566	-0.024	9.612
	Unk.	1.1													
2	Northeast	151.4	-5.281	-4.077	-0.446	-0.010	0.297	3.884	4.614	-0.069	0.000	1.303	0.742	-0.152	5.455
	Midwest	723.7	-8.032	-2.448	-0.215	0.021	0.260	2.433	5.668	0.025	0.000	0.768	0.475	-0.412	13.144
	South	977.9	-4.899	-2.899	-0.265	0.017	0.292	2.919	5.193	0.010	0.000	0.916	0.557	-0.041	7.278
	West	1,379.2	-5.574	-3.500	-0.299	0.032	0.381	3.480	6.431	0.028	0.000	1.195	0.680	-0.068	5.726
	Unk.	8.2													
3	Northeast	1,139.1	-6.360	-4.446	-0.314	0.012	0.319	4.585	6.659	0.008	0.000	1.645	0.632	0.077	5.178
	Midwest	2,053.7	-5.513	-3.009	-0.161	0.046	0.248	3.049	5.112	0.039	0.000	0.890	0.409	-0.040	9.273
	South	3,274.4	-6.032	-3.688	-0.228	0.020	0.272	3.743	6.317	0.016	0.000	1.178	0.500	-0.019	6.898
	West	3,219.9	-5.898	-3.945	-0.260	0.021	0.306	4.010	5.982	0.024	0.000	1.345	0.566	0.022	5.776
	Unk.	44.1	-4.933	-3.911	-0.322	-0.035	0.145	4.065	5.475	-0.101	0.000	1.270	0.468	0.144	6.907
4	Northeast	1,198.0	-5.852	-4.418	-0.138	0.018	0.176	4.514	6.261	0.036	0.000	1.470	0.314	0.094	6.706
	Midwest	6,606.5	-6.027	-3.643	-0.138	0.023	0.182	3.625	5.924	0.024	0.000	0.967	0.320	0.012	11.990
	South	9,844.6	-5.780	-4.033	-0.140	0.005	0.150	4.089	5.981	0.003	0.000	1.096	0.291	0.049	10.607
	West	9,748.3	-6.055	-4.222	-0.144	0.022	0.190	4.247	6.177	0.022	0.000	1.225	0.334	-0.014	8.919
	Unk.	295.0	-5.194	-3.340	-0.134	0.006	0.143	3.612	6.187	0.010	0.079	0.928	0.277	0.381	13.255
5	Northeast	65.9	-5.924	-5.425	-0.081	0.052	0.217	5.635	6.272	0.103	0.000	2.418	0.298	0.033	3.857
	Midwest	1,686.8	-6.290	-3.719	-0.099	0.039	0.176	3.937	5.671	0.036	0.000	0.977	0.275	0.041	13.862
	South	346.7	-5.968	-2.946	-0.078	0.028	0.142	2.410	6.730	0.016	0.020	0.682	0.220	-0.913	29.395
	West	5,340.7	-5.569	-3.411	-0.106	0.013	0.134	3.663	6.233	0.020	0.011	0.961	0.240	0.196	12.042
	Unk.	214.9	-5.605	-4.593	-0.122	0.013	0.149	4.675	5.913	0.029	0.079	1.289	0.271	0.190	9.193
6	Northeast	116.7	-6.548	-5.621	-0.077	0.051	0.184	5.930	6.578	0.061	0.000	2.053	0.261	0.055	5.168
	Midwest	2.2													
	South	28.1	-6.045	-5.765	-0.087	0.074	0.605	6.265	7.015	0.242	0.000	2.519	0.692	0.164	3.698
	West	5.2													
	Unk.	0.0													
7	Northeast	96.3	-5.877	-4.883	-0.038	0.066	0.166	5.143	6.430	0.062	0.000	1.629	0.204	0.078	7.015
	Midwest	0.0													
	South	131.6	-6.762	-5.566	-0.105	0.056	0.234	6.008	6.666	0.024	0.000	2.277	0.339	0.077	4.562
	West	0.2													
	Unk.	0.0													
8	Northeast	136.4	-6.024	-4.462	-0.010	0.054	0.118	4.629	6.757	0.064	0.000	0.987	0.128	0.270	23.684
	Midwest	0.0													
	South	48.9	-6.376	-5.541	-0.066	0.054	0.176	6.129	6.821	0.106	0.000	1.838	0.242	0.228	7.394
	West	0.0													
	Unk.	0.0													

Table 9. Cross level (unfiltered) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	666.5	-5.172	-2.090	-0.312	-0.002	0.302	1.973	4.910	-0.006	0.000	0.718	0.614	-0.117	7.498
	Concrete	27.1	-2.864	-2.078	-0.253	-0.044	0.151	1.166	3.124	-0.075	0.000	0.536	0.404	-0.540	8.111
	Unk.	32.2	-2.358	-1.425	-0.153	0.052	0.295	1.637	3.011	0.087	0.000	0.521	0.448	0.510	6.580
2	Timber	2,486.9	-7.829	-3.184	-0.254	0.022	0.295	3.123	6.273	0.015	0.000	0.979	0.549	-0.128	8.079
	Concrete	556.8	-5.591	-3.481	-0.436	0.027	0.564	3.525	5.905	0.035	0.000	1.308	1.000	-0.016	4.601
	Unk.	196.8	-8.154	-3.295	-0.221	0.024	0.261	2.954	3.945	-0.001	0.000	0.926	0.482	-0.933	11.854
3	Timber	7,334.0	-6.237	-3.776	-0.225	0.022	0.277	3.854	6.443	0.022	0.000	1.209	0.502	0.007	7.018
	Concrete	1,316.7	-6.120	-4.138	-0.240	0.028	0.281	4.326	6.521	0.024	0.000	1.426	0.521	0.084	5.826
	Unk.	1,080.6	-5.940	-3.911	-0.215	0.039	0.270	3.939	6.178	0.020	0.000	1.275	0.485	-0.053	6.529
4	Timber	20,261.4	-6.026	-4.000	-0.142	0.017	0.177	4.047	5.983	0.018	0.000	1.091	0.319	0.019	10.537
	Concrete	4,275.8	-5.978	-4.349	-0.144	0.015	0.167	4.396	6.161	0.006	0.000	1.307	0.311	-0.003	7.913
	Unk.	3,155.1	-5.837	-4.094	-0.132	0.009	0.153	4.180	6.182	0.021	0.000	1.133	0.284	0.124	10.541
5	Timber	5,817.0	-6.017	-3.475	-0.111	0.013	0.138	3.634	6.034	0.017	0.011	0.958	0.249	0.134	12.673
	Concrete	1,123.5	-5.563	-3.612	-0.059	0.060	0.182	3.838	6.308	0.063	0.066	0.955	0.240	0.019	12.945
	Unk.	714.7	-5.952	-4.640	-0.111	0.012	0.133	4.740	6.187	0.029	0.000	1.234	0.244	0.287	11.149
6	Timber	6.1													
	Concrete	1.9													
	Unk.	144.3	-6.545	-5.632	-0.078	0.055	0.206	6.014	6.925	0.096	0.000	2.156	0.284	0.108	4.797
7	Timber	0.3													
	Concrete	0.0													
	Unk.	227.7	-6.752	-5.416	-0.072	0.062	0.197	5.724	6.643	0.040	0.000	2.029	0.269	0.071	5.409
8	Timber	0.0													
	Concrete	0.0													
	Unk.	185.3	-6.258	-5.267	-0.018	0.054	0.127	5.696	6.809	0.075	0.000	1.268	0.145	0.306	15.010

Table 10. Cross level (unfiltered) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	526.1	-5.100	-2.141	-0.317	-0.005	0.304	2.021	4.940	-0.008	0.000	0.733	0.621	-0.087	7.555
	Prim. Frgt.	189.8	-5.637	-1.874	-0.269	0.005	0.280	1.825	4.052	0.001	0.000	0.632	0.548	-0.221	7.134
	Prim. Pass.	9.8													
2	Frgt. Only	2,160.4	-5.159	-2.989	-0.249	0.024	0.302	2.955	5.535	0.019	0.000	0.934	0.551	-0.095	7.325
	Prim. Frgt.	984.5	-8.062	-3.586	-0.315	0.020	0.353	3.464	6.484	0.014	0.000	1.196	0.668	-0.158	6.469
	Prim. Pass.	95.6	-5.677	-4.847	-0.310	0.004	0.312	4.200	5.393	0.024	0.000	1.504	0.623	-0.014	5.446
3	Frgt. Only	5,270.0	-5.657	-3.136	-0.181	0.034	0.250	3.158	5.626	0.030	0.000	0.940	0.431	-0.079	8.493
	Prim. Frgt.	3,806.2	-6.003	-4.064	-0.343	0.011	0.356	4.141	6.296	0.009	0.000	1.470	0.699	0.027	4.978
	Prim. Pass.	655.0	-6.390	-4.840	-0.226	0.024	0.267	5.179	6.694	0.035	0.000	1.860	0.493	0.104	4.695
4	Frgt. Only	12,395.6	-5.564	-3.234	-0.137	0.016	0.172	3.315	5.918	0.021	0.000	0.846	0.309	0.099	13.703
	Prim. Frgt.	14,497.1	-5.981	-4.353	-0.148	0.015	0.173	4.409	6.102	0.011	0.000	1.311	0.321	0.007	7.946
	Prim. Pass.	799.5	-6.155	-4.775	-0.095	0.031	0.165	4.879	6.315	0.051	0.000	1.448	0.260	0.056	8.132
5	Frgt. Only	2,608.3	-5.459	-3.022	-0.088	0.029	0.146	3.104	5.464	0.021	0.000	0.739	0.234	-0.080	19.897
	Prim. Frgt.	4,770.1	-6.086	-3.759	-0.112	0.015	0.145	4.001	6.076	0.029	0.011	1.062	0.258	0.193	10.746
	Prim. Pass.	276.7	-5.973	-5.033	-0.105	0.015	0.125	5.343	6.372	-0.006	0.000	1.525	0.229	0.088	7.914
6	Frgt. Only	1.7													
	Prim. Frgt.	5.3													
	Prim. Pass.	145.3	-6.545	-5.631	-0.076	0.056	0.208	6.013	6.922	0.097	0.000	2.149	0.283	0.107	4.828
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	227.6	-6.752	-5.416	-0.072	0.061	0.197	5.725	6.643	0.040	0.000	2.030	0.269	0.072	5.405
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	185.3	-6.258	-5.267	-0.018	0.054	0.127	5.696	6.809	0.075	0.000	1.268	0.145	0.306	15.010

Cross level (200-foot Filter)

Table 11. Cross level (200-foot filter) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	725.8	-1.644	-0.544	-0.089	0.000	0.089	0.544	1.663	0.000	-0.258	0.191	0.178	-0.002	7.007
2	3,240.5	-1.171	-0.366	-0.058	0.000	0.058	0.367	1.153	0.000	-0.074	0.127	0.116	0.019	8.489
3	9,731.3	-0.954	-0.261	-0.045	0.000	0.045	0.262	0.978	0.000	-0.075	0.093	0.091	0.026	9.971
4	27,692.3	-0.759	-0.193	-0.036	0.000	0.036	0.193	0.763	0.000	-0.034	0.070	0.072	0.002	9.349
5	7,655.1	-0.644	-0.158	-0.031	0.000	0.031	0.159	0.633	0.000	-0.065	0.059	0.062	0.017	8.922
6	152.2	-0.889	-0.178	-0.029	0.000	0.029	0.181	0.802	0.000	-0.057	0.063	0.058	0.096	14.151
7	228.0	-0.639	-0.155	-0.029	0.000	0.028	0.157	0.724	0.000	-0.084	0.057	0.057	0.076	11.369
8	185.3	-0.517	-0.128	-0.024	0.000	0.024	0.132	0.634	0.000	0.036	0.048	0.048	0.240	12.560

Table 12. Cross level (200-foot filter) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	430.5	-1.414	-0.529	-0.085	0.000	0.084	0.529	1.461	0.000	-0.319	0.185	0.169	0.010	6.851
	Curved	295.2	-2.129	-0.566	-0.095	0.001	0.096	0.564	1.889	0.000	-0.269	0.201	0.191	-0.017	7.079
2	Tang.	1,837.0	-1.162	-0.383	-0.061	0.000	0.060	0.384	1.139	0.000	-0.157	0.133	0.121	0.010	7.833
	Curved	1,403.5	-1.180	-0.340	-0.055	0.000	0.055	0.342	1.191	0.000	-0.138	0.119	0.111	0.037	9.530
3	Tang.	5,747.9	-0.946	-0.264	-0.045	0.000	0.045	0.266	0.981	0.000	-0.048	0.094	0.090	0.043	9.240
	Curved	3,983.4	-0.973	-0.255	-0.046	0.000	0.045	0.257	0.967	0.000	0.064	0.092	0.091	-0.001	11.111
4	Tang.	20,961.2	-0.754	-0.193	-0.036	0.000	0.036	0.193	0.747	0.000	-0.033	0.070	0.072	0.005	9.094
	Curved	6,731.0	-0.781	-0.193	-0.037	0.000	0.037	0.193	0.824	0.000	-0.069	0.071	0.075	-0.005	10.080
5	Tang.	6,345.5	-0.639	-0.156	-0.031	0.000	0.031	0.157	0.632	0.000	-0.072	0.058	0.061	0.013	9.035
	Curved	1,309.7	-0.657	-0.166	-0.033	0.000	0.033	0.168	0.643	0.000	0.010	0.062	0.066	0.032	8.387
6	Tang.	93.3	-0.817	-0.185	-0.029	0.000	0.029	0.187	0.850	0.000	0.036	0.063	0.057	0.122	13.167
	Curved	58.9	-0.962	-0.168	-0.030	0.000	0.030	0.172	0.748	0.000	-0.302	0.062	0.060	0.051	15.823
7	Tang.	150.2	-0.670	-0.158	-0.028	0.000	0.028	0.159	0.776	0.000	-0.051	0.057	0.056	0.039	12.673
	Curved	77.8	-0.478	-0.151	-0.030	0.000	0.029	0.154	0.619	0.000	0.009	0.056	0.059	0.150	8.668
8	Tang.	157.9	-0.520	-0.129	-0.024	0.000	0.024	0.131	0.645	0.000	-0.074	0.048	0.048	0.207	13.152
	Curved	27.4	-0.440	-0.122	-0.026	0.000	0.025	0.133	0.480	0.000	0.023	0.048	0.051	0.425	9.269

Table 13. Cross level (200-foot filter) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	30.7	-1.272	-0.526	-0.072	0.001	0.075	0.508	1.454	0.000	-0.542	0.175	0.148	-0.017	8.690
	Midwest	132.3	-1.485	-0.511	-0.089	0.000	0.088	0.523	1.456	0.000	-0.269	0.184	0.177	0.050	6.730
	South	331.5	-1.707	-0.588	-0.098	0.001	0.099	0.585	1.693	0.000	-0.449	0.209	0.198	-0.020	6.305
	West	230.1	-1.944	-0.485	-0.079	0.000	0.078	0.486	1.734	0.000	-0.293	0.170	0.157	0.007	8.145
	Unk.	1.1													
2	Northeast	151.4	-1.144	-0.429	-0.067	0.000	0.067	0.424	1.180	0.000	-0.189	0.148	0.134	-0.027	6.689
	Midwest	723.7	-1.154	-0.407	-0.068	0.000	0.068	0.408	1.086	0.000	-0.141	0.143	0.135	-0.007	6.776
	South	977.9	-1.227	-0.373	-0.063	0.000	0.063	0.374	1.255	0.000	-0.069	0.131	0.126	0.054	8.915
	West	1,379.2	-1.150	-0.321	-0.051	0.000	0.050	0.323	1.103	0.000	-0.085	0.111	0.101	0.021	9.407
	Unk.	8.2													
3	Northeast	1,139.1	-1.012	-0.271	-0.044	0.000	0.044	0.272	0.983	0.000	0.083	0.093	0.088	0.003	10.472
	Midwest	2,053.7	-0.909	-0.262	-0.046	0.000	0.046	0.263	0.899	0.000	-0.128	0.094	0.092	0.020	8.231
	South	3,274.4	-0.979	-0.275	-0.048	0.000	0.048	0.277	1.047	0.000	-0.093	0.098	0.096	0.069	9.738
	West	3,219.9	-0.928	-0.241	-0.043	0.000	0.043	0.243	0.917	0.000	0.065	0.087	0.086	-0.024	11.243
	Unk.	44.1	-0.813	-0.244	-0.040	0.000	0.040	0.244	0.838	0.000	-0.277	0.085	0.081	-0.039	9.561
4	Northeast	1,198.0	-0.765	-0.180	-0.035	0.000	0.035	0.180	0.741	0.000	-0.037	0.067	0.070	0.012	10.273
	Midwest	6,606.5	-0.734	-0.189	-0.036	0.000	0.036	0.189	0.745	0.000	-0.046	0.069	0.071	0.003	8.659
	South	9,844.6	-0.779	-0.202	-0.038	0.000	0.038	0.203	0.789	0.000	-0.067	0.074	0.077	0.002	9.557
	West	9,748.3	-0.732	-0.187	-0.035	0.000	0.035	0.187	0.743	0.000	-0.075	0.068	0.069	0.002	9.073
	Unk.	295.0	-0.995	-0.179	-0.031	0.000	0.031	0.180	0.861	0.000	0.033	0.065	0.062	-0.058	16.796
5	Northeast	65.9	-0.754	-0.160	-0.027	0.000	0.027	0.164	0.588	0.000	-0.172	0.058	0.055	-0.041	14.567
	Midwest	1,686.8	-0.626	-0.158	-0.029	0.000	0.029	0.159	0.643	0.000	-0.066	0.057	0.058	0.022	9.878
	South	346.7	-0.715	-0.191	-0.033	0.000	0.033	0.193	0.620	0.000	0.020	0.068	0.066	-0.029	9.196
	West	5,340.7	-0.626	-0.155	-0.032	0.000	0.032	0.156	0.632	0.000	-0.026	0.058	0.063	0.019	8.456
	Unk.	214.9	-0.620	-0.166	-0.032	0.000	0.032	0.168	0.619	0.000	-0.068	0.061	0.065	0.043	9.154
6	Northeast	116.7	-0.759	-0.175	-0.029	0.000	0.028	0.176	0.651	0.000	-0.057	0.061	0.057	0.027	12.243
	Midwest	2.2													
	South	28.1	-0.978	-0.197	-0.031	0.000	0.031	0.198	0.971	0.000	-0.302	0.070	0.062	0.240	19.576
	West	5.2													
	Unk.	0.0													
7	Northeast	96.3	-0.624	-0.144	-0.027	0.000	0.027	0.145	0.603	0.000	-0.073	0.053	0.054	0.042	11.436
	Midwest	0.0													
	South	131.6	-0.639	-0.162	-0.030	0.000	0.030	0.164	0.805	0.000	-0.084	0.059	0.060	0.089	11.139
	West	0.2													
	Unk.	0.0													
8	Northeast	136.4	-0.522	-0.122	-0.023	0.000	0.023	0.124	0.628	0.000	-0.074	0.045	0.047	0.208	12.037
	Midwest	0.0													
	South	48.9	-0.491	-0.147	-0.027	0.000	0.026	0.153	0.647	0.000	0.069	0.054	0.053	0.288	12.592
	West	0.0													
	Unk.	0.0													

Table 14. Cross level (200-foot filter) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	666.5	-1.654	-0.548	-0.091	0.000	0.091	0.548	1.674	0.000	-0.223	0.194	0.183	-0.002	6.850
	Concrete	27.1	-1.282	-0.425	-0.050	0.000	0.050	0.428	1.647	0.000	-0.305	0.140	0.100	0.104	12.293
	Unk.	32.2	-1.468	-0.534	-0.078	-0.001	0.079	0.535	1.315	0.000	-0.329	0.182	0.156	-0.053	7.887
2	Timber	2,486.9	-1.171	-0.388	-0.066	0.000	0.066	0.389	1.161	0.000	-0.085	0.137	0.132	0.020	7.567
	Concrete	556.8	-1.069	-0.216	-0.036	0.000	0.036	0.217	1.015	0.000	-0.077	0.077	0.072	0.034	14.653
	Unk.	196.8	-1.241	-0.320	-0.052	0.000	0.052	0.319	1.158	0.000	-0.166	0.111	0.103	-0.026	9.245
3	Timber	7,334.0	-0.978	-0.271	-0.049	0.000	0.049	0.273	0.994	0.000	0.074	0.097	0.098	0.012	9.467
	Concrete	1,316.7	-0.763	-0.187	-0.033	0.000	0.033	0.190	0.791	0.000	-0.071	0.068	0.066	0.060	10.557
	Unk.	1,080.6	-0.911	-0.250	-0.041	0.000	0.040	0.254	0.994	0.000	-0.068	0.087	0.081	0.132	10.505
4	Timber	20,261.4	-0.771	-0.200	-0.039	0.000	0.039	0.200	0.776	0.000	-0.075	0.073	0.077	-0.005	8.676
	Concrete	4,275.8	-0.656	-0.157	-0.029	0.000	0.028	0.158	0.662	0.000	-0.038	0.057	0.057	0.051	10.589
	Unk.	3,155.1	-0.783	-0.183	-0.033	0.000	0.033	0.183	0.779	0.000	-0.072	0.066	0.065	0.020	12.264
5	Timber	5,817.0	-0.641	-0.162	-0.033	0.000	0.033	0.163	0.641	0.000	0.044	0.061	0.066	0.012	8.331
	Concrete	1,123.5	-0.621	-0.130	-0.024	0.000	0.024	0.132	0.612	0.000	-0.040	0.048	0.048	0.048	12.663
	Unk.	714.7	-0.670	-0.153	-0.029	0.000	0.029	0.156	0.607	0.000	-0.066	0.057	0.058	0.033	9.993
6	Timber	6.1													
	Concrete	1.9													
	Unk.	144.3	-0.889	-0.175	-0.029	0.000	0.029	0.177	0.727	0.000	-0.057	0.062	0.058	0.038	13.603
7	Timber	0.3													
	Concrete	0.0													
	Unk.	227.7	-0.639	-0.155	-0.029	0.000	0.028	0.157	0.725	0.000	-0.084	0.057	0.057	0.075	11.378
8	Timber	0.0													
	Concrete	0.0													
	Unk.	185.3	-0.517	-0.128	-0.024	0.000	0.024	0.132	0.634	0.000	0.036	0.048	0.048	0.240	12.560

Table 15. Cross level (200-foot filter) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	526.1	-1.467	-0.552	-0.091	0.001	0.092	0.552	1.677	0.000	-0.258	0.195	0.183	0.018	6.592
	Prim. Frgt.	189.8	-2.269	-0.521	-0.082	0.000	0.082	0.521	1.585	0.000	-0.180	0.182	0.164	-0.067	8.440
	Prim. Pass.	9.8													
2	Frgt. Only	2,160.4	-1.179	-0.387	-0.063	0.000	0.063	0.388	1.153	0.000	-0.069	0.135	0.126	0.008	7.611
	Prim. Frgt.	984.5	-1.134	-0.311	-0.049	0.000	0.049	0.312	1.174	0.000	-0.183	0.108	0.099	0.069	11.339
	Prim. Pass.	95.6	-0.984	-0.327	-0.053	0.000	0.053	0.329	0.892	0.000	-0.127	0.114	0.106	0.016	8.039
3	Frgt. Only	5,270.0	-0.944	-0.269	-0.047	0.000	0.047	0.271	0.993	0.000	-0.067	0.096	0.094	0.040	8.765
	Prim. Frgt.	3,806.2	-0.967	-0.250	-0.043	0.000	0.043	0.252	0.951	0.000	-0.076	0.089	0.086	0.000	12.112
	Prim. Pass.	655.0	-1.018	-0.246	-0.043	0.000	0.042	0.251	0.913	0.000	-0.064	0.088	0.085	0.025	9.582
4	Frgt. Only	12,395.6	-0.771	-0.200	-0.038	0.000	0.038	0.200	0.771	0.000	-0.076	0.073	0.075	-0.006	8.846
	Prim. Frgt.	14,497.1	-0.749	-0.186	-0.035	0.000	0.035	0.186	0.758	0.000	-0.034	0.068	0.070	0.009	9.808
	Prim. Pass.	799.5	-0.766	-0.191	-0.035	0.000	0.035	0.193	0.741	0.000	-0.037	0.070	0.070	0.041	9.562
5	Frgt. Only	2,608.3	-0.629	-0.150	-0.029	0.000	0.028	0.151	0.651	0.000	-0.033	0.055	0.057	0.034	10.059
	Prim. Frgt.	4,770.1	-0.645	-0.162	-0.033	0.000	0.033	0.163	0.622	0.000	-0.065	0.061	0.065	0.009	8.358
	Prim. Pass.	276.7	-0.699	-0.153	-0.029	0.000	0.029	0.153	0.580	0.000	-0.095	0.056	0.058	0.037	9.897
6	Frgt. Only	1.7													
	Prim. Frgt.	5.3													
	Prim. Pass.	145.3	-0.889	-0.176	-0.029	0.000	0.029	0.178	0.727	0.000	-0.057	0.062	0.058	0.049	13.441
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	227.6	-0.639	-0.155	-0.029	0.000	0.028	0.157	0.725	0.000	-0.084	0.057	0.057	0.073	11.379
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	185.3	-0.517	-0.128	-0.024	0.000	0.024	0.132	0.634	0.000	0.036	0.048	0.048	0.240	12.560

Mean Alignment (Space Curve, Unfiltered)

Table 16. Mean alignment (space curve, unfiltered) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-9.190	-3.757	-0.126	0.001	0.118	3.629	8.928	-0.005	0.012	1.018	0.243	-0.284	25.243
3	5,521.8	-9.811	-4.908	-0.189	0.000	0.188	4.935	9.819	0.001	0.000	1.458	0.377	0.022	10.959
4	22,485.4	-8.829	-2.334	-0.104	0.000	0.104	2.337	8.881	0.000	0.000	0.665	0.208	0.027	22.795
5	6,722.9	-7.115	-0.845	-0.075	0.000	0.074	0.852	7.665	0.000	0.000	0.274	0.149	0.112	74.331
6	136.1	-2.863	-0.914	-0.081	0.001	0.082	0.937	1.987	0.000	0.003	0.290	0.162	-0.039	8.666
7	186.6	-2.659	-0.628	-0.070	0.001	0.072	0.613	2.161	0.000	0.019	0.202	0.142	-0.253	12.173
8	158.1	-0.991	-0.431	-0.050	0.001	0.051	0.426	1.078	0.000	0.000	0.128	0.101	0.033	11.220

Table 17. Mean alignment (space curve, unfiltered) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-8.937	-1.456	-0.094	0.006	0.097	1.663	8.663	0.006	0.041	0.534	0.191	-0.241	89.190
	Curved	9.3													
3	Tang.	3,381.9	-9.205	-2.763	-0.107	0.000	0.107	2.725	9.010	0.000	0.000	0.744	0.214	-0.027	28.835
	Curved	2,139.9	-9.885	-6.109	-0.833	-0.003	0.837	6.159	9.877	0.002	0.000	2.148	1.670	0.018	5.355
4	Tang.	17,049.2	-6.122	-1.207	-0.081	0.000	0.080	1.184	6.124	-0.001	0.000	0.355	0.161	-0.112	43.858
	Curved	5,436.2	-9.262	-3.506	-0.407	0.001	0.410	3.517	9.396	0.003	0.000	1.199	0.817	0.022	7.900
5	Tang.	5,562.2	-3.917	-0.500	-0.064	0.000	0.065	0.511	3.140	0.000	0.000	0.175	0.129	-0.333	45.813
	Curved	1,160.6	-8.666	-1.381	-0.202	-0.003	0.202	1.375	8.752	0.000	0.000	0.536	0.404	0.145	26.908
6	Tang.	82.2	-2.956	-0.613	-0.057	0.000	0.056	0.547	1.998	-0.003	0.006	0.177	0.113	-0.596	20.798
	Curved	54.0	-1.815	-1.078	-0.165	0.004	0.177	1.085	1.897	0.005	0.009	0.406	0.342	0.009	4.567
7	Tang.	120.4	-1.820	-0.451	-0.059	0.000	0.059	0.404	1.046	-0.002	0.019	0.138	0.118	-0.416	10.918
	Curved	66.2	-2.786	-0.743	-0.105	0.002	0.118	0.739	2.167	0.004	0.000	0.283	0.222	-0.201	7.764
8	Tang.	132.8	-1.006	-0.294	-0.046	0.001	0.047	0.271	1.024	-0.001	0.000	0.097	0.093	-0.206	11.099
	Curved	25.3	-0.952	-0.617	-0.083	0.002	0.092	0.643	1.106	0.004	0.013	0.230	0.175	0.075	4.893

Table 18. Mean alignment (space curve, unfiltered) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-1.600	-0.733	-0.102	0.002	0.102	0.733	1.941	0.002	-0.041	0.238	0.204	0.399	13.758
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-9.736	-4.286	-0.218	-0.002	0.216	4.321	9.839	0.001	0.000	1.370	0.435	0.007	9.917
	Midwest	1,274.7	-9.368	-3.506	-0.127	0.000	0.127	3.498	9.106	0.001	0.013	1.007	0.254	0.018	16.541
	South	1,859.4	-9.795	-4.798	-0.199	-0.001	0.198	4.766	9.717	-0.001	0.000	1.410	0.397	-0.020	11.415
	West	1,727.3	-9.878	-5.666	-0.247	0.001	0.250	5.777	9.861	0.003	-0.013	1.787	0.497	0.044	8.221
	Unk.	23.0	-8.382	-4.671	-0.167	-0.004	0.155	4.122	8.565	-0.037	0.006	1.286	0.322	-0.130	14.069
4	Northeast	1,020.6	-9.060	-1.828	-0.110	0.000	0.109	1.827	9.031	0.001	0.013	0.573	0.219	0.134	20.617
	Midwest	5,525.3	-8.212	-1.823	-0.092	0.000	0.093	1.813	8.126	0.000	0.000	0.512	0.185	0.027	26.630
	South	7,924.4	-9.064	-2.509	-0.112	0.000	0.111	2.521	9.213	0.000	0.000	0.716	0.222	0.054	24.491
	West	7,780.1	-8.534	-2.539	-0.106	0.000	0.106	2.540	8.540	0.000	0.003	0.722	0.212	0.001	17.253
	Unk.	235.0	-9.132	-1.722	-0.078	0.000	0.076	1.631	8.263	-0.003	0.016	0.481	0.153	-0.844	51.324
5	Northeast	61.0	-3.618	-1.327	-0.094	0.000	0.096	1.321	7.703	0.002	-0.003	0.446	0.190	0.266	12.086
	Midwest	1,509.1	-8.464	-0.916	-0.068	0.000	0.067	0.919	8.263	0.000	0.000	0.277	0.135	0.045	73.833
	South	305.1	-3.007	-0.821	-0.077	0.000	0.079	0.816	2.929	0.000	-0.009	0.247	0.156	-0.043	16.484
	West	4,657.7	-6.341	-0.805	-0.076	0.000	0.076	0.810	7.307	0.000	0.000	0.270	0.153	0.135	75.754
	Unk.	190.1	-8.767	-0.884	-0.081	0.001	0.081	0.891	8.320	0.000	0.013	0.315	0.162	0.082	127.682
6	Northeast	104.9	-2.917	-0.926	-0.080	0.000	0.078	0.946	1.996	-0.001	0.006	0.292	0.158	-0.051	8.746
	Midwest	2.1													
	South	24.9	-1.776	-0.844	-0.083	0.003	0.096	0.842	1.399	0.002	-0.032	0.274	0.179	-0.092	6.593
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.387	-0.634	-0.068	0.000	0.069	0.621	1.086	0.000	0.016	0.199	0.137	-0.105	7.963
	Midwest	0.0													
	South	103.1	-1.845	-0.619	-0.072	0.001	0.074	0.605	2.162	0.001	-0.009	0.201	0.147	-0.029	11.967
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-1.013	-0.391	-0.047	0.001	0.048	0.385	1.091	0.000	0.000	0.117	0.095	0.077	12.992
	Midwest	0.0													
	South	40.9	-0.950	-0.501	-0.059	0.002	0.061	0.506	0.879	0.001	0.006	0.156	0.121	-0.028	8.026
	West	0.0													
	Unk.	0.0													

Table 19. Mean alignment (space curve, unfiltered) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-6.322	-2.539	-0.117	-0.001	0.107	2.649	6.081	-0.009	0.012	0.664	0.224	-0.431	30.187
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-9.787	-4.692	-0.188	-0.001	0.187	4.700	9.808	0.000	0.000	1.381	0.375	0.022	11.611
	Concrete	724.6	-9.826	-5.621	-0.203	0.000	0.207	5.641	9.788	-0.001	0.000	1.740	0.410	-0.003	8.567
	Unk.	573.2	-9.877	-5.265	-0.182	-0.001	0.177	5.418	9.847	0.004	0.013	1.612	0.359	0.057	9.876
4	Timber	16,606.0	-8.835	-2.226	-0.107	0.000	0.107	2.230	8.918	0.000	0.000	0.640	0.213	0.050	25.325
	Concrete	3,342.8	-8.561	-2.810	-0.099	0.000	0.098	2.803	8.561	-0.002	0.000	0.797	0.197	-0.015	14.490
	Unk.	2,536.6	-8.968	-2.184	-0.093	0.000	0.092	2.214	8.857	0.001	0.000	0.634	0.185	-0.016	24.789
5	Timber	5,052.1	-6.627	-0.797	-0.078	0.000	0.077	0.798	7.485	0.000	0.000	0.260	0.155	0.176	77.837
	Concrete	1,000.0	-4.711	-1.024	-0.061	0.000	0.062	1.028	5.462	0.001	0.000	0.297	0.123	0.010	31.684
	Unk.	670.8	-8.625	-0.981	-0.072	0.000	0.073	1.018	8.752	0.001	-0.006	0.332	0.145	-0.023	93.370
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-2.872	-0.904	-0.081	0.000	0.081	0.926	1.988	0.000	0.003	0.288	0.162	-0.058	8.440
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-2.659	-0.627	-0.070	0.001	0.072	0.613	2.161	0.000	0.019	0.202	0.142	-0.230	12.095
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.991	-0.431	-0.050	0.001	0.051	0.426	1.078	0.000	0.000	0.128	0.101	0.033	11.220

Table 20. Mean alignment (space curve, unfiltered) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-9.190	-3.425	-0.119	0.001	0.113	3.500	8.928	0.002	0.012	0.966	0.232	-0.226	30.344
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-9.629	-4.133	-0.147	0.000	0.147	4.167	9.759	0.001	0.013	1.184	0.294	0.034	14.690
	Prim. Frgt.	2,090.9	-9.869	-5.647	-0.312	0.000	0.315	5.699	9.851	0.001	-0.013	1.782	0.627	0.020	7.976
	Prim. Pass.	351.9	-9.785	-4.884	-0.217	-0.002	0.208	4.797	9.795	-0.004	0.003	1.498	0.424	-0.030	9.451
4	Frgt. Only	10,050.2	-7.229	-1.989	-0.097	0.000	0.097	1.986	7.887	0.000	0.000	0.549	0.194	0.069	23.436
	Prim. Frgt.	11,799.6	-9.035	-2.617	-0.111	0.000	0.110	2.619	9.085	0.000	0.000	0.750	0.221	0.012	20.514
	Prim. Pass.	635.6	-9.135	-2.166	-0.111	0.000	0.111	2.207	9.321	0.002	0.016	0.658	0.222	0.048	18.615
5	Frgt. Only	2,314.9	-4.738	-0.739	-0.062	0.000	0.061	0.737	5.042	0.000	0.000	0.218	0.124	0.105	36.430
	Prim. Frgt.	4,171.3	-7.912	-0.856	-0.082	0.000	0.082	0.865	7.977	0.000	0.000	0.287	0.164	0.115	74.708
	Prim. Pass.	236.7	-8.107	-1.283	-0.095	0.002	0.100	1.322	8.915	0.004	-0.006	0.466	0.195	0.055	46.165
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-2.870	-0.903	-0.081	0.000	0.081	0.925	1.988	0.000	0.003	0.288	0.163	-0.058	8.442
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.733	-0.624	-0.070	0.001	0.072	0.613	2.161	0.001	0.019	0.200	0.142	-0.038	10.112
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.991	-0.431	-0.050	0.001	0.051	0.426	1.078	0.000	0.000	0.128	0.101	0.033	11.220

Mean Alignment (Space Curve, 200-foot Filter)

Table 21. Mean alignment (space curve, 200-foot filter) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-0.796	-0.238	-0.038	0.000	0.038	0.232	0.994	0.000	-0.131	0.083	0.076	0.061	13.949
3	5,521.8	-1.347	-0.306	-0.047	0.000	0.047	0.307	1.295	0.000	0.063	0.106	0.094	-0.003	12.832
4	22,485.4	-1.005	-0.205	-0.037	0.000	0.037	0.204	0.998	0.000	-0.070	0.074	0.074	-0.005	11.974
5	6,722.9	-0.871	-0.152	-0.031	0.000	0.031	0.152	0.938	0.000	0.032	0.058	0.061	0.013	12.561
6	136.1	-0.584	-0.148	-0.026	0.000	0.026	0.149	0.500	0.000	-0.075	0.053	0.053	0.008	9.632
7	186.6	-0.593	-0.126	-0.024	0.000	0.025	0.122	0.549	0.000	-0.072	0.046	0.049	-0.068	10.247
8	158.1	-0.380	-0.103	-0.021	0.000	0.021	0.100	0.319	0.000	-0.064	0.038	0.042	-0.108	7.672

Table 22. Mean alignment (space curve, 200-foot filter) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-0.659	-0.189	-0.035	0.000	0.036	0.190	0.658	0.000	-0.050	0.069	0.071	0.027	9.874
	Curved	9.3													
3	Tang.	3,381.9	-0.893	-0.220	-0.040	0.000	0.040	0.220	0.929	0.000	-0.039	0.080	0.081	0.000	8.705
	Curved	2,139.9	-1.468	-0.400	-0.062	0.000	0.062	0.401	1.465	0.000	-0.132	0.138	0.124	-0.005	10.069
4	Tang.	17,049.2	-0.703	-0.178	-0.034	0.000	0.034	0.178	0.692	0.000	-0.070	0.065	0.069	0.000	8.576
	Curved	5,436.2	-1.164	-0.267	-0.046	0.000	0.046	0.267	1.214	0.000	-0.065	0.096	0.093	-0.009	11.635
5	Tang.	5,562.2	-0.583	-0.148	-0.030	0.000	0.030	0.148	0.544	0.000	0.042	0.055	0.060	-0.012	7.881
	Curved	1,160.6	-1.106	-0.170	-0.035	0.000	0.035	0.168	1.237	0.000	0.049	0.067	0.070	0.079	22.012
6	Tang.	82.2	-0.604	-0.143	-0.025	0.000	0.025	0.149	0.511	0.000	0.019	0.051	0.049	0.018	10.993
	Curved	54.0	-0.539	-0.154	-0.029	0.000	0.030	0.148	0.481	0.000	-0.016	0.056	0.059	-0.003	8.031
7	Tang.	120.4	-0.574	-0.123	-0.024	0.000	0.024	0.121	0.584	0.000	0.017	0.045	0.047	0.037	10.881
	Curved	66.2	-0.595	-0.131	-0.025	0.000	0.026	0.123	0.531	0.000	-0.006	0.048	0.052	-0.228	9.255
8	Tang.	132.8	-0.382	-0.103	-0.021	0.000	0.021	0.101	0.322	0.000	-0.042	0.038	0.042	-0.109	7.909
	Curved	25.3	-0.308	-0.100	-0.021	0.000	0.022	0.098	0.249	0.000	-0.063	0.038	0.043	-0.105	6.394

Table 23. Mean alignment (space curve, 200-foot filter) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-0.529	-0.173	-0.035	0.000	0.035	0.165	0.612	0.000	-0.050	0.064	0.069	0.078	8.232
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-1.297	-0.267	-0.044	0.000	0.044	0.268	1.075	0.000	-0.080	0.094	0.088	-0.089	12.457
	Midwest	1,274.7	-1.374	-0.260	-0.042	0.000	0.042	0.262	1.310	0.000	-0.038	0.094	0.084	-0.013	16.743
	South	1,859.4	-1.370	-0.310	-0.050	0.000	0.049	0.311	1.370	0.000	-0.079	0.108	0.099	0.005	12.279
	West	1,727.3	-1.291	-0.341	-0.050	0.000	0.050	0.341	1.283	0.000	-0.098	0.116	0.100	0.018	11.216
	Unk.	23.0	-1.476	-0.282	-0.041	0.000	0.041	0.288	0.854	0.000	-0.196	0.101	0.082	-0.828	22.968
4	Northeast	1,020.6	-0.885	-0.180	-0.035	0.000	0.035	0.179	0.920	0.000	-0.068	0.068	0.071	-0.019	11.629
	Midwest	5,525.3	-0.911	-0.190	-0.035	0.000	0.035	0.189	0.883	0.000	-0.087	0.070	0.071	-0.018	10.771
	South	7,924.4	-1.065	-0.231	-0.040	0.000	0.040	0.231	1.030	0.000	-0.083	0.082	0.081	-0.006	11.666
	West	7,780.1	-0.998	-0.189	-0.035	0.000	0.035	0.189	1.041	0.000	-0.039	0.069	0.070	0.008	12.062
	Unk.	235.0	-0.949	-0.161	-0.032	0.000	0.031	0.163	0.920	0.000	-0.085	0.060	0.063	0.024	12.355
5	Northeast	61.0	-0.727	-0.143	-0.025	0.000	0.025	0.143	0.847	0.000	0.076	0.052	0.050	-0.245	17.720
	Midwest	1,509.1	-0.852	-0.151	-0.029	0.000	0.029	0.150	1.003	0.000	-0.036	0.056	0.058	0.046	14.602
	South	305.1	-0.650	-0.184	-0.031	0.000	0.031	0.181	0.632	0.000	-0.120	0.064	0.063	-0.090	8.801
	West	4,657.7	-0.880	-0.151	-0.031	0.000	0.031	0.151	0.905	0.000	-0.032	0.058	0.063	-0.005	11.634
	Unk.	190.1	-0.928	-0.143	-0.031	0.000	0.031	0.142	1.448	0.000	-0.087	0.056	0.061	0.519	28.783
6	Northeast	104.9	-0.518	-0.142	-0.026	0.000	0.026	0.144	0.507	0.000	-0.034	0.051	0.052	0.037	9.557
	Midwest	2.1													
	South	24.9	-0.659	-0.167	-0.028	0.000	0.028	0.162	0.487	0.000	-0.090	0.058	0.056	-0.078	10.416
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-0.455	-0.122	-0.024	0.000	0.024	0.119	0.407	0.000	-0.072	0.045	0.048	-0.025	8.023
	Midwest	0.0													
	South	103.1	-0.607	-0.129	-0.024	0.000	0.025	0.123	0.505	0.000	0.017	0.047	0.049	-0.123	10.607
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.372	-0.103	-0.020	0.000	0.021	0.101	0.312	0.000	-0.042	0.038	0.041	-0.116	7.930
	Midwest	0.0													
	South	40.9	-0.381	-0.101	-0.022	0.000	0.023	0.098	0.341	0.000	-0.147	0.039	0.045	-0.088	6.976
	West	0.0													
	Unk.	0.0													

Table 24. Mean alignment (space curve, 200-foot filter) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-0.656	-0.208	-0.036	0.000	0.037	0.202	0.994	0.000	-0.050	0.074	0.073	0.077	11.148
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-1.330	-0.305	-0.049	0.000	0.049	0.306	1.266	0.000	-0.079	0.107	0.098	-0.007	12.289
	Concrete	724.6	-1.243	-0.302	-0.041	0.000	0.041	0.302	1.315	0.000	-0.175	0.102	0.082	-0.015	15.213
	Unk.	573.2	-1.450	-0.320	-0.044	0.000	0.043	0.321	1.418	0.000	-0.144	0.107	0.087	0.038	14.207
4	Timber	16,606.0	-1.010	-0.209	-0.038	0.000	0.038	0.209	0.988	0.000	-0.064	0.076	0.076	0.000	11.369
	Concrete	3,342.8	-0.942	-0.185	-0.032	0.000	0.032	0.185	1.026	0.000	-0.074	0.067	0.065	-0.015	13.854
	Unk.	2,536.6	-1.027	-0.196	-0.035	0.000	0.035	0.196	1.041	0.000	-0.071	0.071	0.069	-0.033	14.213
5	Timber	5,052.1	-0.856	-0.157	-0.032	0.000	0.032	0.157	0.904	0.000	0.042	0.060	0.065	-0.002	10.932
	Concrete	1,000.0	-0.676	-0.130	-0.025	0.000	0.025	0.129	0.597	0.000	0.041	0.048	0.050	-0.073	12.139
	Unk.	670.8	-1.008	-0.142	-0.028	0.000	0.028	0.141	1.226	0.000	-0.058	0.055	0.057	0.239	26.953
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-0.589	-0.148	-0.026	0.000	0.026	0.148	0.501	0.000	-0.075	0.053	0.052	0.009	9.870
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-0.593	-0.126	-0.024	0.000	0.025	0.122	0.549	0.000	-0.072	0.046	0.049	-0.066	10.263
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.380	-0.103	-0.021	0.000	0.021	0.100	0.319	0.000	-0.064	0.038	0.042	-0.108	7.672

Table 25. Mean alignment (space curve, 200-foot filter) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-0.797	-0.219	-0.036	0.000	0.037	0.226	0.904	0.000	-0.131	0.080	0.073	0.032	14.524
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-1.175	-0.279	-0.045	0.000	0.045	0.280	1.188	0.000	-0.076	0.099	0.090	0.017	12.691
	Prim. Frgt.	2,090.9	-1.442	-0.342	-0.050	0.000	0.050	0.340	1.441	0.000	-0.098	0.117	0.101	-0.022	12.326
	Prim. Pass.	351.9	-1.479	-0.303	-0.046	0.000	0.046	0.306	1.282	0.000	-0.046	0.105	0.092	0.011	12.787
4	Frgt. Only	10,050.2	-0.941	-0.196	-0.037	0.000	0.037	0.196	0.916	0.000	-0.041	0.072	0.074	-0.006	10.403
	Prim. Frgt.	11,799.6	-1.041	-0.212	-0.037	0.000	0.037	0.212	1.047	0.000	-0.038	0.076	0.074	-0.006	13.020
	Prim. Pass.	635.6	-0.858	-0.197	-0.035	0.000	0.035	0.196	0.857	0.000	-0.103	0.071	0.070	0.021	10.758
5	Frgt. Only	2,314.9	-0.732	-0.135	-0.027	0.000	0.027	0.135	0.653	0.000	-0.067	0.051	0.054	-0.028	10.827
	Prim. Frgt.	4,171.3	-0.917	-0.159	-0.033	0.000	0.033	0.159	1.059	0.000	-0.066	0.061	0.066	0.026	12.508
	Prim. Pass.	236.7	-0.867	-0.166	-0.031	0.000	0.031	0.167	0.893	0.000	-0.066	0.061	0.062	0.005	13.980
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-0.588	-0.149	-0.026	0.000	0.026	0.150	0.501	0.000	-0.075	0.053	0.053	0.008	9.747
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-0.593	-0.126	-0.024	0.000	0.024	0.121	0.499	0.000	-0.072	0.046	0.049	-0.081	9.615
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.380	-0.103	-0.021	0.000	0.021	0.100	0.319	0.000	-0.064	0.038	0.042	-0.108	7.672

Left & Right Alignment (Space Curve, Unfiltered)

Table 26. L&R alignment (space curve, unfiltered) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-9.189	-3.762	-0.129	0.000	0.121	3.629	8.924	-0.005	0.000	1.019	0.250	-0.284	25.194
3	5,521.8	-9.816	-4.909	-0.195	0.000	0.195	4.936	9.828	0.001	0.000	1.459	0.390	0.022	10.945
4	22,485.4	-8.829	-2.335	-0.110	0.000	0.110	2.338	8.886	0.000	0.000	0.667	0.220	0.027	22.651
5	6,722.9	-7.111	-0.848	-0.080	0.000	0.080	0.854	7.664	0.000	0.000	0.277	0.161	0.110	71.507
6	136.1	-2.868	-0.916	-0.085	0.000	0.086	0.937	1.982	0.000	0.000	0.292	0.171	-0.038	8.553
7	186.6	-2.682	-0.630	-0.073	0.000	0.075	0.614	2.183	0.000	0.000	0.203	0.148	-0.249	11.937
8	158.1	-1.000	-0.433	-0.052	0.000	0.053	0.428	1.086	0.000	0.000	0.130	0.105	0.032	10.862

Table 27. L&R alignment (space curve, unfiltered) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-8.936	-1.459	-0.097	0.004	0.101	1.656	8.663	0.006	0.000	0.535	0.197	-0.238	88.463
	Curved	9.3													
3	Tang.	3,381.9	-9.196	-2.762	-0.113	0.000	0.113	2.726	9.001	0.000	0.000	0.746	0.226	-0.027	28.644
	Curved	2,139.9	-9.900	-6.110	-0.834	-0.002	0.838	6.159	9.898	0.002	0.000	2.148	1.672	0.018	5.354
4	Tang.	17,049.2	-6.134	-1.208	-0.086	0.000	0.086	1.185	6.135	-0.001	0.000	0.357	0.172	-0.110	42.773
	Curved	5,436.2	-9.269	-3.507	-0.409	0.000	0.412	3.518	9.414	0.003	0.000	1.199	0.821	0.022	7.892
5	Tang.	5,562.2	-3.911	-0.506	-0.070	0.000	0.070	0.517	3.154	0.000	0.000	0.180	0.140	-0.308	41.781
	Curved	1,160.6	-8.660	-1.382	-0.205	-0.003	0.205	1.377	8.749	0.000	0.000	0.537	0.410	0.144	26.694
6	Tang.	82.2	-2.945	-0.612	-0.061	0.000	0.060	0.552	2.020	-0.003	0.000	0.180	0.121	-0.570	19.852
	Curved	54.0	-1.844	-1.078	-0.169	0.003	0.179	1.089	1.904	0.005	0.000	0.407	0.348	0.009	4.553
7	Tang.	120.4	-1.835	-0.452	-0.061	0.000	0.061	0.409	1.086	-0.002	0.000	0.140	0.122	-0.401	10.588
	Curved	66.2	-2.794	-0.746	-0.108	0.002	0.120	0.743	2.191	0.004	0.000	0.284	0.228	-0.200	7.694
8	Tang.	132.8	-1.009	-0.297	-0.048	0.000	0.049	0.275	1.022	-0.001	0.000	0.099	0.097	-0.193	10.592
	Curved	25.3	-0.962	-0.615	-0.086	0.002	0.095	0.645	1.118	0.004	0.000	0.231	0.180	0.074	4.857

Table 28. L&R alignment (space curve, unfiltered) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-1.624	-0.733	-0.105	0.001	0.105	0.734	1.951	0.002	0.000	0.240	0.209	0.387	13.361
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-9.770	-4.290	-0.224	-0.002	0.222	4.321	9.869	0.001	0.000	1.371	0.446	0.007	9.906
	Midwest	1,274.7	-9.372	-3.507	-0.133	0.000	0.133	3.500	9.135	0.001	0.000	1.008	0.266	0.018	16.491
	South	1,859.4	-9.797	-4.799	-0.206	-0.001	0.204	4.766	9.731	-0.001	0.000	1.411	0.410	-0.020	11.398
	West	1,727.3	-9.874	-5.667	-0.253	0.001	0.256	5.778	9.880	0.003	0.000	1.788	0.509	0.044	8.215
	Unk.	23.0	-8.405	-4.665	-0.174	-0.004	0.163	4.119	8.571	-0.037	0.000	1.287	0.336	-0.130	14.043
4	Northeast	1,020.6	-9.043	-1.830	-0.116	0.000	0.116	1.830	9.032	0.001	0.000	0.575	0.232	0.134	20.459
	Midwest	5,525.3	-8.217	-1.824	-0.097	0.000	0.098	1.814	8.117	0.000	0.000	0.513	0.195	0.026	26.377
	South	7,924.4	-9.071	-2.511	-0.118	0.000	0.117	2.522	9.216	0.000	0.000	0.717	0.236	0.053	24.337
	West	7,780.1	-8.532	-2.539	-0.113	0.000	0.113	2.541	8.551	0.000	0.000	0.724	0.225	0.001	17.166
	Unk.	235.0	-9.098	-1.723	-0.082	0.000	0.080	1.630	8.260	-0.003	0.000	0.482	0.162	-0.838	50.845
5	Northeast	61.0	-3.680	-1.328	-0.097	0.000	0.099	1.319	7.708	0.002	0.000	0.447	0.196	0.264	12.046
	Midwest	1,509.1	-8.463	-0.918	-0.072	0.000	0.072	0.920	8.262	0.000	0.000	0.280	0.144	0.045	71.590
	South	305.1	-2.994	-0.825	-0.082	0.000	0.084	0.818	2.933	0.000	0.000	0.249	0.166	-0.041	15.954
	West	4,657.7	-6.351	-0.807	-0.083	0.000	0.082	0.813	7.296	0.000	0.000	0.273	0.165	0.131	72.567
	Unk.	190.1	-8.772	-0.890	-0.088	0.000	0.088	0.894	8.313	0.000	0.000	0.318	0.176	0.081	123.603
6	Northeast	104.9	-2.917	-0.929	-0.085	0.000	0.082	0.948	2.010	-0.001	0.000	0.294	0.167	-0.049	8.633
	Midwest	2.1													
	South	24.9	-1.773	-0.843	-0.087	0.003	0.098	0.843	1.478	0.002	0.000	0.276	0.185	-0.091	6.526
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.404	-0.634	-0.071	0.000	0.073	0.624	1.130	0.000	0.000	0.201	0.144	-0.101	7.811
	Midwest	0.0													
	South	103.1	-1.840	-0.621	-0.075	0.001	0.077	0.605	2.186	0.001	0.000	0.202	0.151	-0.031	11.776
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-1.013	-0.393	-0.049	0.000	0.050	0.386	1.096	0.000	0.000	0.119	0.099	0.074	12.480
	Midwest	0.0													
	South	40.9	-0.949	-0.503	-0.061	0.001	0.064	0.508	0.936	0.001	0.000	0.157	0.125	-0.027	7.868
	West	0.0													
	Unk.	0.0													

Table 29. L&R alignment (space curve, unfiltered) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-6.387	-2.530	-0.121	-0.002	0.110	2.651	6.103	-0.009	0.000	0.665	0.230	-0.431	30.051
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-9.796	-4.692	-0.195	0.000	0.195	4.700	9.824	0.000	0.000	1.382	0.389	0.022	11.592
	Concrete	724.6	-9.824	-5.621	-0.208	0.000	0.211	5.638	9.789	-0.001	0.000	1.741	0.419	-0.003	8.563
	Unk.	573.2	-9.871	-5.265	-0.188	0.000	0.183	5.418	9.878	0.004	0.000	1.613	0.371	0.057	9.869
4	Timber	16,606.0	-8.842	-2.228	-0.113	0.000	0.113	2.230	8.915	0.000	0.000	0.642	0.226	0.050	25.133
	Concrete	3,342.8	-8.560	-2.810	-0.103	0.000	0.103	2.803	8.564	-0.002	0.000	0.798	0.206	-0.015	14.459
	Unk.	2,536.6	-8.965	-2.185	-0.099	0.000	0.098	2.215	8.864	0.001	0.000	0.635	0.198	-0.017	24.622
5	Timber	5,052.1	-6.640	-0.800	-0.085	0.000	0.084	0.801	7.494	0.000	0.000	0.264	0.169	0.170	74.117
	Concrete	1,000.0	-4.725	-1.024	-0.064	0.000	0.064	1.029	5.451	0.001	0.000	0.298	0.129	0.010	31.299
	Unk.	670.8	-8.636	-0.983	-0.077	0.000	0.078	1.018	8.738	0.001	0.000	0.334	0.155	-0.023	91.374
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-2.869	-0.906	-0.085	0.000	0.085	0.926	1.992	0.000	0.000	0.290	0.170	-0.057	8.332
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-2.682	-0.628	-0.073	0.000	0.075	0.615	2.183	0.000	0.000	0.203	0.148	-0.227	11.861
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-1.000	-0.433	-0.052	0.000	0.053	0.428	1.086	0.000	0.000	0.130	0.105	0.032	10.862

Table 30. L&R alignment (space curve, unfiltered) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-9.189	-3.427	-0.122	0.000	0.115	3.501	8.925	0.002	0.000	0.966	0.237	-0.225	30.279
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-9.629	-4.135	-0.154	0.000	0.154	4.168	9.756	0.001	0.000	1.185	0.308	0.034	14.656
	Prim. Frgt.	2,090.9	-9.870	-5.648	-0.316	0.000	0.319	5.701	9.861	0.001	0.000	1.782	0.635	0.020	7.971
	Prim. Pass.	351.9	-9.854	-4.885	-0.223	-0.002	0.213	4.796	9.777	-0.004	0.000	1.498	0.436	-0.030	9.442
4	Frgt. Only	10,050.2	-7.222	-1.990	-0.103	0.000	0.103	1.987	7.879	0.000	0.000	0.551	0.205	0.069	23.208
	Prim. Frgt.	11,799.6	-9.039	-2.618	-0.117	0.000	0.117	2.620	9.093	0.000	0.000	0.752	0.234	0.012	20.417
	Prim. Pass.	635.6	-9.167	-2.169	-0.116	0.000	0.116	2.209	9.321	0.002	0.000	0.659	0.232	0.047	18.520
5	Frgt. Only	2,314.9	-4.731	-0.740	-0.067	0.000	0.066	0.738	5.041	0.000	0.000	0.221	0.134	0.101	34.761
	Prim. Frgt.	4,171.3	-7.892	-0.859	-0.089	0.000	0.088	0.867	7.978	0.000	0.000	0.290	0.177	0.112	71.794
	Prim. Pass.	236.7	-8.104	-1.285	-0.100	0.002	0.104	1.323	8.924	0.004	0.000	0.468	0.204	0.055	45.771
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-2.869	-0.904	-0.085	0.000	0.086	0.925	1.991	0.000	0.000	0.289	0.171	-0.056	8.335
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.749	-0.626	-0.073	0.000	0.075	0.615	2.183	0.001	0.000	0.201	0.148	-0.038	9.932
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-1.000	-0.433	-0.052	0.000	0.053	0.428	1.086	0.000	0.000	0.130	0.105	0.032	10.862

Left & Right Alignment (Space Curve, 200-foot Filter)

Table 31. L&R alignment (space curve, 200-foot filter) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-0.841	-0.248	-0.043	0.000	0.043	0.242	0.978	0.000	-0.112	0.089	0.086	0.030	12.123
3	5,521.8	-1.360	-0.318	-0.054	0.000	0.054	0.319	1.317	0.000	-0.083	0.113	0.108	-0.003	10.958
4	22,485.4	-1.020	-0.222	-0.043	0.000	0.043	0.222	1.030	0.000	-0.067	0.082	0.087	-0.002	9.531
5	6,722.9	-0.888	-0.177	-0.037	0.000	0.037	0.177	0.960	0.000	0.069	0.067	0.074	0.017	9.083
6	136.1	-0.616	-0.162	-0.031	0.000	0.031	0.163	0.591	0.000	0.036	0.059	0.062	0.005	8.329
7	186.6	-0.638	-0.137	-0.028	0.000	0.028	0.134	0.628	0.000	-0.100	0.051	0.056	-0.048	9.286
8	158.1	-0.415	-0.113	-0.023	0.000	0.024	0.112	0.445	0.000	-0.074	0.043	0.047	-0.081	7.317

Table 32. L&R alignment (space curve, 200-foot filter) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-0.840	-0.205	-0.040	0.000	0.041	0.202	0.689	0.000	-0.252	0.076	0.081	-0.005	8.732
	Curved	9.3													
3	Tang.	3,381.9	-0.908	-0.240	-0.048	0.000	0.048	0.240	0.944	0.000	-0.022	0.089	0.095	-0.002	7.163
	Curved	2,139.9	-1.502	-0.409	-0.067	0.000	0.067	0.410	1.497	0.000	-0.092	0.143	0.135	-0.005	9.362
4	Tang.	17,049.2	-0.742	-0.199	-0.041	0.000	0.041	0.199	0.733	0.000	-0.064	0.075	0.082	0.001	7.011
	Curved	5,436.2	-1.212	-0.279	-0.051	0.000	0.051	0.278	1.230	0.000	-0.072	0.102	0.103	-0.006	10.318
5	Tang.	5,562.2	-0.610	-0.173	-0.037	0.000	0.036	0.174	0.591	0.000	-0.044	0.066	0.073	0.003	6.393
	Curved	1,160.6	-1.147	-0.191	-0.040	0.000	0.040	0.190	1.296	0.000	-0.077	0.075	0.080	0.061	16.401
6	Tang.	82.2	-0.620	-0.159	-0.029	0.000	0.029	0.162	0.576	0.000	-0.051	0.058	0.059	0.011	9.280
	Curved	54.0	-0.607	-0.165	-0.034	0.000	0.034	0.163	0.593	0.000	-0.035	0.062	0.068	-0.001	7.147
7	Tang.	120.4	-0.682	-0.133	-0.027	0.000	0.027	0.132	0.623	0.000	-0.090	0.050	0.054	0.023	10.220
	Curved	66.2	-0.596	-0.143	-0.029	0.000	0.030	0.137	0.668	0.000	-0.037	0.053	0.059	-0.156	7.872
8	Tang.	132.8	-0.428	-0.112	-0.023	0.000	0.023	0.111	0.456	0.000	-0.074	0.042	0.047	-0.087	7.653
	Curved	25.3	-0.318	-0.116	-0.024	0.000	0.025	0.114	0.291	0.000	-0.153	0.044	0.049	-0.055	5.711

Table 33. L&R alignment (space curve, 200-foot filter) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-0.550	-0.189	-0.039	0.000	0.040	0.181	0.641	0.000	-0.153	0.071	0.079	0.050	7.066
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-1.294	-0.282	-0.050	0.000	0.050	0.282	1.116	0.000	-0.040	0.101	0.100	-0.071	10.666
	Midwest	1,274.7	-1.380	-0.278	-0.049	0.000	0.049	0.279	1.342	0.000	-0.083	0.102	0.098	-0.014	13.399
	South	1,859.4	-1.371	-0.322	-0.057	0.000	0.057	0.323	1.385	0.000	-0.095	0.116	0.114	0.004	10.452
	West	1,727.3	-1.316	-0.350	-0.057	0.000	0.057	0.350	1.313	0.000	-0.077	0.122	0.114	0.015	9.953
	Unk.	23.0	-1.514	-0.295	-0.047	0.000	0.048	0.297	0.885	0.000	-0.548	0.108	0.095	-0.681	18.561
4	Northeast	1,020.6	-0.922	-0.201	-0.041	0.000	0.041	0.199	0.913	0.000	-0.064	0.076	0.083	-0.014	9.236
	Midwest	5,525.3	-0.922	-0.207	-0.041	0.000	0.041	0.206	0.906	0.000	0.073	0.077	0.083	-0.014	8.785
	South	7,924.4	-1.083	-0.247	-0.047	0.000	0.047	0.247	1.083	0.000	-0.067	0.091	0.095	-0.002	9.424
	West	7,780.1	-1.012	-0.207	-0.041	0.000	0.041	0.207	1.053	0.000	-0.072	0.078	0.083	0.006	9.341
	Unk.	235.0	-0.978	-0.175	-0.037	0.000	0.037	0.178	0.918	0.000	-0.049	0.067	0.073	0.004	9.926
5	Northeast	61.0	-0.804	-0.154	-0.028	0.000	0.028	0.153	0.915	0.000	-0.053	0.057	0.056	-0.222	15.168
	Midwest	1,509.1	-0.850	-0.172	-0.034	0.000	0.034	0.172	0.991	0.000	-0.042	0.064	0.068	0.038	10.821
	South	305.1	-0.702	-0.196	-0.037	0.000	0.037	0.194	0.647	0.000	-0.090	0.071	0.075	-0.063	7.246
	West	4,657.7	-0.904	-0.177	-0.038	0.000	0.038	0.178	0.927	0.000	-0.063	0.068	0.076	0.007	8.394
	Unk.	190.1	-0.951	-0.168	-0.038	0.000	0.038	0.168	1.502	0.000	-0.125	0.066	0.075	0.332	17.228
6	Northeast	104.9	-0.531	-0.157	-0.030	0.000	0.031	0.158	0.554	0.000	-0.067	0.058	0.061	0.035	8.127
	Midwest	2.1													
	South	24.9	-0.697	-0.175	-0.032	0.000	0.032	0.177	0.607	0.000	-0.174	0.063	0.064	-0.072	9.787
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-0.498	-0.134	-0.028	0.000	0.028	0.132	0.494	0.000	-0.080	0.051	0.057	0.001	7.142
	Midwest	0.0													
	South	103.1	-0.694	-0.139	-0.027	0.000	0.028	0.134	0.631	0.000	-0.100	0.051	0.055	-0.109	10.053
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.443	-0.113	-0.023	0.000	0.023	0.111	0.442	0.000	-0.068	0.042	0.046	-0.096	7.641
	Midwest	0.0													
	South	40.9	-0.378	-0.114	-0.025	0.000	0.025	0.112	0.524	0.000	-0.045	0.044	0.050	-0.043	6.495
	West	0.0													
	Unk.	0.0													

Table 34. L&R alignment (space curve, 200-foot filter) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-0.837	-0.221	-0.042	0.000	0.042	0.211	0.960	0.000	-0.202	0.080	0.084	0.030	9.728
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-1.350	-0.318	-0.056	0.000	0.056	0.318	1.305	0.000	-0.083	0.114	0.113	-0.006	10.375
	Concrete	724.6	-1.247	-0.308	-0.045	0.000	0.046	0.309	1.314	0.000	-0.151	0.106	0.091	-0.015	13.760
	Unk.	573.2	-1.460	-0.330	-0.049	0.000	0.049	0.332	1.462	0.000	-0.160	0.113	0.098	0.031	12.484
4	Timber	16,606.0	-1.025	-0.227	-0.045	0.000	0.045	0.227	1.028	0.000	0.063	0.085	0.091	0.002	8.998
	Concrete	3,342.8	-0.947	-0.195	-0.036	0.000	0.037	0.195	1.028	0.000	0.045	0.072	0.073	-0.011	11.682
	Unk.	2,536.6	-1.063	-0.214	-0.041	0.000	0.041	0.214	1.050	0.000	0.063	0.079	0.082	-0.026	11.028
5	Timber	5,052.1	-0.876	-0.183	-0.040	0.000	0.040	0.183	0.934	0.000	0.069	0.070	0.079	0.008	7.931
	Concrete	1,000.0	-0.685	-0.141	-0.028	0.000	0.028	0.140	0.618	0.000	-0.031	0.053	0.057	-0.049	10.266
	Unk.	670.8	-0.987	-0.162	-0.034	0.000	0.034	0.162	1.235	0.000	-0.064	0.063	0.068	0.165	18.084
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-0.620	-0.161	-0.031	0.000	0.031	0.162	0.591	0.000	0.036	0.059	0.061	0.010	8.571
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-0.638	-0.137	-0.028	0.000	0.028	0.133	0.629	0.000	-0.100	0.051	0.056	-0.046	9.300
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.415	-0.113	-0.023	0.000	0.024	0.112	0.445	0.000	-0.074	0.043	0.047	-0.081	7.317

Table 35. L&R alignment (space curve, 200-foot filter) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-0.805	-0.232	-0.041	0.000	0.042	0.233	0.889	0.000	-0.112	0.085	0.083	0.016	12.307
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-1.205	-0.294	-0.053	0.000	0.053	0.295	1.222	0.000	-0.083	0.107	0.105	0.011	10.454
	Prim. Frgt.	2,090.9	-1.465	-0.351	-0.057	0.000	0.057	0.350	1.453	0.000	-0.070	0.122	0.113	-0.019	10.988
	Prim. Pass.	351.9	-1.485	-0.315	-0.052	0.000	0.052	0.317	1.340	0.000	-0.135	0.111	0.105	0.012	11.169
4	Frgt. Only	10,050.2	-0.949	-0.215	-0.044	0.000	0.044	0.215	0.937	0.000	0.063	0.081	0.087	-0.002	8.249
	Prim. Frgt.	11,799.6	-1.068	-0.228	-0.043	0.000	0.043	0.228	1.085	0.000	-0.066	0.084	0.086	-0.004	10.457
	Prim. Pass.	635.6	-0.895	-0.212	-0.041	0.000	0.041	0.211	0.879	0.000	-0.073	0.078	0.081	0.014	8.950
5	Frgt. Only	2,314.9	-0.741	-0.157	-0.033	0.000	0.033	0.157	0.693	0.000	-0.046	0.060	0.065	-0.010	8.251
	Prim. Frgt.	4,171.3	-0.929	-0.185	-0.040	0.000	0.040	0.186	1.054	0.000	0.069	0.071	0.080	0.026	8.911
	Prim. Pass.	236.7	-0.900	-0.180	-0.035	0.000	0.036	0.181	0.933	0.000	-0.065	0.068	0.071	-0.006	11.174
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-0.619	-0.161	-0.031	0.000	0.031	0.163	0.591	0.000	0.036	0.059	0.062	0.010	8.489
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-0.638	-0.136	-0.028	0.000	0.028	0.133	0.595	0.000	-0.100	0.051	0.056	-0.059	8.787
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.415	-0.113	-0.023	0.000	0.024	0.112	0.445	0.000	-0.074	0.043	0.047	-0.081	7.317

Left & Right Alignment (31-foot MCO)

Table 36. L&R alignment (31-foot MCO) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	68.7	-0.853	-0.191	-0.037	0.000	0.037	0.190	0.771	0.000	0.000	0.070	0.074	-0.002	9.509
3	5,825.6	-0.763	-0.225	-0.048	0.000	0.048	0.224	0.766	0.000	0.000	0.085	0.096	-0.001	5.807
4	22,633.4	-0.667	-0.200	-0.043	0.000	0.043	0.201	0.672	0.000	0.000	0.077	0.087	0.005	5.717
5	6,751.5	-0.628	-0.203	-0.042	0.000	0.042	0.203	0.642	0.000	0.000	0.076	0.083	0.014	6.070
6	136.1	-0.564	-0.158	-0.034	0.000	0.034	0.156	0.556	0.000	0.000	0.060	0.068	-0.036	6.414
7	186.6	-0.741	-0.137	-0.030	0.000	0.031	0.135	0.644	0.000	0.000	0.053	0.060	-0.032	8.421
8	158.1	-0.446	-0.122	-0.026	0.000	0.027	0.124	0.435	0.000	0.000	0.047	0.053	-0.002	5.935

Table 37. L&R alignment (31-foot MCO) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	32.7	-0.809	-0.174	-0.034	0.000	0.034	0.173	0.755	0.000	0.000	0.064	0.068	-0.038	9.944
	Curved	36.0	-0.871	-0.206	-0.040	0.000	0.040	0.203	0.811	0.000	0.000	0.075	0.079	0.018	8.969
3	Tang.	3,522.2	-0.702	-0.222	-0.048	0.000	0.048	0.221	0.706	0.000	0.000	0.085	0.096	-0.002	5.434
	Curved	2,303.4	-0.829	-0.230	-0.048	0.000	0.048	0.230	0.840	0.000	0.000	0.087	0.096	0.000	6.315
4	Tang.	17,157.5	-0.656	-0.200	-0.043	0.000	0.043	0.201	0.659	0.000	0.000	0.077	0.087	0.006	5.650
	Curved	5,475.9	-0.695	-0.201	-0.043	0.000	0.043	0.201	0.710	0.000	0.000	0.076	0.085	0.001	5.932
5	Tang.	5,586.4	-0.602	-0.203	-0.042	0.000	0.042	0.203	0.617	0.000	0.000	0.076	0.083	0.014	5.964
	Curved	1,165.1	-0.753	-0.200	-0.040	0.000	0.040	0.201	0.751	0.000	0.000	0.075	0.081	0.015	6.595
6	Tang.	82.2	-0.576	-0.159	-0.033	0.000	0.034	0.159	0.578	0.000	0.000	0.061	0.067	-0.037	7.219
	Curved	54.0	-0.492	-0.155	-0.034	0.000	0.035	0.153	0.471	0.000	0.000	0.060	0.069	-0.034	5.109
7	Tang.	120.4	-0.821	-0.134	-0.029	0.000	0.030	0.134	0.656	0.000	0.000	0.053	0.059	-0.027	10.243
	Curved	66.2	-0.433	-0.141	-0.031	0.000	0.032	0.138	0.510	0.000	0.000	0.054	0.063	-0.041	5.346
8	Tang.	132.8	-0.455	-0.122	-0.026	0.000	0.027	0.124	0.455	0.000	0.000	0.047	0.053	0.000	6.107
	Curved	25.3	-0.322	-0.127	-0.027	0.000	0.027	0.126	0.394	0.000	0.000	0.048	0.055	-0.009	5.087

Table 38. L&R alignment (31-foot MCO) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.8													
	Midwest	2.6													
	South	20.2	-0.449	-0.161	-0.035	0.000	0.035	0.163	0.577	0.000	0.000	0.062	0.071	0.028	5.711
	West	42.3	-0.870	-0.199	-0.037	0.000	0.037	0.196	0.743	0.000	0.000	0.072	0.073	-0.038	8.906
	Unk.	0.9													
3	Northeast	670.3	-0.729	-0.210	-0.044	0.000	0.044	0.210	0.749	0.000	0.000	0.080	0.089	0.004	6.462
	Midwest	1,324.5	-0.786	-0.229	-0.047	0.000	0.048	0.229	0.794	0.000	0.000	0.086	0.095	-0.005	5.961
	South	1,927.0	-0.759	-0.231	-0.050	0.000	0.050	0.231	0.751	0.000	0.000	0.088	0.100	0.000	5.620
	West	1,879.7	-0.761	-0.220	-0.047	0.000	0.048	0.219	0.771	0.000	0.000	0.084	0.095	0.000	5.660
	Unk.	24.1	-0.521	-0.218	-0.045	0.000	0.045	0.216	0.580	0.000	0.000	0.081	0.091	-0.001	5.368
4	Northeast	1,023.2	-0.623	-0.190	-0.041	0.000	0.041	0.190	0.639	0.000	0.000	0.072	0.082	-0.004	5.794
	Midwest	5,567.2	-0.656	-0.192	-0.041	0.000	0.041	0.192	0.661	0.000	0.000	0.073	0.082	0.001	5.959
	South	7,958.5	-0.689	-0.211	-0.047	0.000	0.047	0.212	0.692	0.000	0.000	0.081	0.093	0.011	5.492
	West	7,848.9	-0.651	-0.196	-0.042	0.000	0.042	0.196	0.657	0.000	0.000	0.075	0.085	0.001	5.710
	Unk.	235.5	-0.656	-0.167	-0.039	0.000	0.039	0.168	0.582	0.000	0.000	0.066	0.079	-0.007	5.504
5	Northeast	61.1	-0.625	-0.144	-0.028	0.000	0.029	0.143	0.630	0.000	0.000	0.054	0.057	-0.020	8.989
	Midwest	1,516.7	-0.634	-0.183	-0.037	0.000	0.037	0.185	0.655	0.000	0.000	0.068	0.073	0.014	6.712
	South	306.2	-0.572	-0.166	-0.038	0.000	0.037	0.166	0.606	0.000	0.000	0.064	0.075	0.030	5.761
	West	4,677.4	-0.629	-0.211	-0.043	0.000	0.043	0.211	0.637	0.000	0.000	0.079	0.087	0.013	5.836
	Unk.	190.1	-0.636	-0.183	-0.043	0.000	0.043	0.185	0.864	0.000	0.000	0.073	0.087	0.027	5.253
6	Northeast	104.9	-0.530	-0.156	-0.034	0.000	0.034	0.154	0.546	0.000	0.000	0.060	0.068	-0.030	6.094
	Midwest	2.1													
	South	24.9	-0.592	-0.154	-0.032	0.000	0.033	0.156	0.574	0.000	0.000	0.059	0.065	-0.030	8.031
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-0.565	-0.135	-0.031	0.000	0.032	0.134	0.605	0.000	0.000	0.054	0.063	-0.009	6.865
	Midwest	0.0													
	South	103.1	-0.849	-0.138	-0.029	0.000	0.029	0.136	0.652	0.000	0.000	0.052	0.058	-0.067	9.449
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.438	-0.122	-0.026	0.000	0.026	0.124	0.416	0.000	0.000	0.047	0.051	-0.002	6.103
	Midwest	0.0													
	South	40.9	-0.456	-0.123	-0.029	0.000	0.029	0.124	0.588	0.000	0.000	0.049	0.059	0.000	5.499
	West	0.0													
	Unk.	0.0													

Table 39. L&R alignment (31-foot MCO) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	32.2	-0.810	-0.198	-0.039	0.000	0.039	0.195	0.823	0.000	0.000	0.073	0.077	-0.003	9.768
	Concrete	34.6	-0.872	-0.179	-0.035	0.000	0.035	0.179	0.749	0.000	0.000	0.066	0.069	-0.031	8.928
	Unk.	1.9													
3	Timber	4,422.3	-0.755	-0.230	-0.051	0.000	0.051	0.230	0.753	0.000	0.000	0.088	0.101	-0.001	5.427
	Concrete	774.4	-0.761	-0.187	-0.038	0.000	0.039	0.188	0.765	0.000	0.000	0.070	0.077	-0.001	7.684
	Unk.	629.0	-0.844	-0.216	-0.044	0.000	0.044	0.215	0.846	0.000	0.000	0.081	0.088	0.001	7.051
4	Timber	16,706.0	-0.673	-0.206	-0.045	0.000	0.045	0.206	0.680	0.000	0.000	0.079	0.090	0.006	5.559
	Concrete	3,372.7	-0.599	-0.164	-0.036	0.000	0.036	0.165	0.584	0.000	0.000	0.063	0.072	0.003	5.921
	Unk.	2,554.7	-0.680	-0.200	-0.043	0.000	0.043	0.201	0.685	0.000	0.000	0.076	0.085	0.003	5.863
5	Timber	5,070.2	-0.635	-0.213	-0.045	0.000	0.045	0.214	0.640	0.000	0.000	0.080	0.090	0.014	5.658
	Concrete	1,009.6	-0.563	-0.141	-0.031	0.000	0.031	0.141	0.606	0.000	0.000	0.055	0.062	0.015	7.704
	Unk.	671.7	-0.644	-0.175	-0.037	0.000	0.037	0.175	0.701	0.000	0.000	0.067	0.075	0.012	6.318
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-0.562	-0.156	-0.033	0.000	0.034	0.154	0.559	0.000	0.000	0.060	0.067	-0.030	6.446
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-0.742	-0.137	-0.030	0.000	0.031	0.135	0.644	0.000	0.000	0.053	0.060	-0.032	8.438
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.446	-0.122	-0.026	0.000	0.027	0.124	0.435	0.000	0.000	0.047	0.053	-0.002	5.935

Table 40. L&R alignment (31-foot MCO) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	4.4													
	Prim. Frgt.	62.4	-0.833	-0.190	-0.037	0.000	0.037	0.189	0.722	0.000	0.000	0.070	0.074	-0.006	8.419
	Prim. Pass.	2.0													
3	Frgt. Only	3,225.2	-0.747	-0.230	-0.050	0.000	0.050	0.230	0.738	0.000	0.000	0.088	0.100	-0.005	5.473
	Prim. Frgt.	2,238.1	-0.790	-0.218	-0.046	0.000	0.046	0.217	0.818	0.000	0.000	0.083	0.092	0.006	6.237
	Prim. Pass.	362.4	-0.729	-0.210	-0.043	0.000	0.043	0.210	0.757	0.000	0.000	0.079	0.086	-0.005	6.585
4	Frgt. Only	10,104.3	-0.653	-0.204	-0.045	0.000	0.044	0.205	0.657	0.000	0.000	0.078	0.089	0.010	5.537
	Prim. Frgt.	11,890.4	-0.684	-0.198	-0.043	0.000	0.043	0.198	0.687	0.000	0.000	0.076	0.085	0.000	5.863
	Prim. Pass.	638.7	-0.592	-0.180	-0.038	0.000	0.039	0.180	0.637	0.000	0.000	0.068	0.077	0.006	5.819
5	Frgt. Only	2,325.5	-0.581	-0.175	-0.036	0.000	0.036	0.174	0.616	0.000	0.000	0.065	0.072	0.002	6.329
	Prim. Frgt.	4,186.7	-0.646	-0.216	-0.045	0.000	0.045	0.217	0.655	0.000	0.000	0.081	0.090	0.018	5.723
	Prim. Pass.	239.3	-0.595	-0.171	-0.036	0.000	0.037	0.169	0.563	0.000	0.000	0.065	0.073	-0.015	5.906
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-0.562	-0.156	-0.034	0.000	0.034	0.155	0.558	0.000	0.000	0.060	0.068	-0.030	6.415
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-0.742	-0.136	-0.030	0.000	0.031	0.135	0.644	0.000	0.000	0.053	0.060	-0.040	8.255
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.446	-0.122	-0.026	0.000	0.027	0.124	0.435	0.000	0.000	0.047	0.053	-0.002	5.935

Left & Right Alignment (62-foot MCO)

Table 41. L&R alignment (62-foot MCO) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	68.7	-1.464	-0.506	-0.062	0.000	0.063	0.510	1.797	0.000	0.000	0.160	0.125	0.092	11.575
3	5,825.6	-1.554	-0.360	-0.066	0.000	0.066	0.360	1.586	0.000	0.000	0.132	0.133	-0.006	9.713
4	22,633.4	-1.204	-0.278	-0.056	0.000	0.056	0.278	1.217	0.000	0.000	0.104	0.112	0.001	8.575
5	6,751.5	-1.056	-0.234	-0.049	0.000	0.049	0.235	1.112	0.000	0.000	0.089	0.098	0.001	8.110
6	136.1	-0.784	-0.211	-0.039	0.000	0.039	0.212	0.751	0.000	0.000	0.077	0.078	-0.016	9.011
7	186.6	-0.939	-0.177	-0.035	0.000	0.035	0.174	0.870	0.000	0.000	0.066	0.070	-0.053	9.903
8	158.1	-0.569	-0.148	-0.030	0.000	0.031	0.148	0.612	0.000	0.000	0.056	0.061	-0.067	7.775

Table 42. L&R alignment (62-foot MCO) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	32.7	-1.089	-0.272	-0.049	0.000	0.050	0.263	1.064	0.000	0.000	0.097	0.099	0.033	9.712
	Curved	36.0	-1.479	-0.608	-0.080	0.000	0.080	0.601	1.808	0.000	0.000	0.201	0.161	0.084	8.430
3	Tang.	3,522.2	-1.211	-0.314	-0.062	0.000	0.062	0.314	1.200	0.000	0.000	0.116	0.124	-0.008	7.553
	Curved	2,303.4	-1.726	-0.420	-0.075	0.000	0.075	0.420	1.748	0.000	0.000	0.152	0.150	-0.006	9.844
4	Tang.	17,157.5	-1.020	-0.266	-0.055	0.000	0.055	0.266	1.019	0.000	0.000	0.100	0.109	0.000	7.516
	Curved	5,475.9	-1.449	-0.312	-0.061	0.000	0.061	0.312	1.472	0.000	0.000	0.117	0.121	0.003	9.925
5	Tang.	5,586.4	-0.814	-0.232	-0.049	0.000	0.049	0.232	0.821	0.000	0.000	0.088	0.098	0.001	6.630
	Curved	1,165.1	-1.559	-0.246	-0.051	0.000	0.051	0.245	1.504	0.000	0.000	0.095	0.102	-0.001	13.248
6	Tang.	82.2	-0.786	-0.211	-0.038	0.000	0.038	0.216	0.750	0.000	0.000	0.077	0.076	-0.018	9.654
	Curved	54.0	-0.776	-0.209	-0.041	0.000	0.042	0.206	0.749	0.000	0.000	0.078	0.082	-0.013	8.094
7	Tang.	120.4	-0.992	-0.174	-0.034	0.000	0.034	0.173	0.886	0.000	0.000	0.065	0.068	0.010	11.224
	Curved	66.2	-0.716	-0.180	-0.036	0.000	0.037	0.175	0.771	0.000	0.000	0.067	0.073	-0.157	7.769
8	Tang.	132.8	-0.570	-0.148	-0.030	0.000	0.031	0.148	0.629	0.000	0.000	0.056	0.061	-0.071	8.075
	Curved	25.3	-0.488	-0.149	-0.031	0.000	0.031	0.149	0.425	0.000	0.000	0.056	0.061	-0.047	6.199

Table 43. L&R alignment (62-foot MCO) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.8													
	Midwest	2.6													
	South	20.2	-0.762	-0.251	-0.053	0.000	0.053	0.245	0.837	0.000	0.000	0.095	0.106	0.057	7.012
	West	42.3	-1.475	-0.570	-0.068	0.000	0.068	0.572	1.808	0.000	0.000	0.184	0.135	0.090	9.817
	Unk.	0.9													
3	Northeast	670.3	-1.654	-0.331	-0.061	0.000	0.062	0.330	1.359	0.000	0.000	0.122	0.123	-0.053	10.711
	Midwest	1,324.5	-1.538	-0.336	-0.063	0.000	0.063	0.336	1.605	0.000	0.000	0.124	0.126	0.002	10.497
	South	1,927.0	-1.533	-0.375	-0.071	0.000	0.071	0.375	1.659	0.000	0.000	0.138	0.141	-0.001	9.273
	West	1,879.7	-1.554	-0.369	-0.067	0.000	0.067	0.370	1.569	0.000	0.000	0.134	0.134	-0.003	9.331
	Unk.	24.1	-1.338	-0.362	-0.062	0.000	0.062	0.355	1.108	0.000	0.000	0.126	0.124	-0.212	9.334
4	Northeast	1,023.2	-1.148	-0.260	-0.053	0.000	0.053	0.259	1.175	0.000	0.000	0.098	0.106	-0.002	8.774
	Midwest	5,567.2	-1.160	-0.269	-0.054	0.000	0.054	0.267	1.164	0.000	0.000	0.101	0.108	-0.007	8.790
	South	7,958.5	-1.247	-0.304	-0.061	0.000	0.061	0.304	1.273	0.000	0.000	0.114	0.122	0.007	8.156
	West	7,848.9	-1.192	-0.258	-0.053	0.000	0.053	0.258	1.195	0.000	0.000	0.097	0.106	0.000	8.496
	Unk.	235.5	-1.198	-0.233	-0.049	0.000	0.049	0.233	0.883	0.000	0.000	0.088	0.098	-0.034	8.441
5	Northeast	61.1	-1.268	-0.204	-0.034	0.000	0.035	0.198	1.167	0.000	0.000	0.073	0.069	-0.047	16.529
	Midwest	1,516.7	-0.985	-0.230	-0.045	0.000	0.045	0.230	1.077	0.000	0.000	0.085	0.090	0.000	9.468
	South	306.2	-0.828	-0.255	-0.050	0.000	0.049	0.253	0.802	0.000	0.000	0.093	0.099	-0.035	7.157
	West	4,677.4	-1.102	-0.235	-0.051	0.000	0.051	0.235	1.113	0.000	0.000	0.090	0.102	-0.001	7.671
	Unk.	190.1	-1.073	-0.220	-0.049	0.000	0.049	0.221	1.488	0.000	0.000	0.086	0.098	0.129	10.259
6	Northeast	104.9	-0.752	-0.205	-0.038	0.000	0.039	0.205	0.757	0.000	0.000	0.075	0.077	0.003	9.036
	Midwest	2.1													
	South	24.9	-0.812	-0.228	-0.040	0.000	0.040	0.229	0.724	0.000	0.000	0.081	0.080	-0.072	9.973
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-0.619	-0.174	-0.036	0.000	0.036	0.171	0.663	0.000	0.000	0.066	0.072	-0.019	7.366
	Midwest	0.0													
	South	103.1	-0.735	-0.177	-0.034	0.000	0.035	0.175	0.761	0.000	0.000	0.066	0.069	-0.068	9.291
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.571	-0.148	-0.030	0.000	0.030	0.149	0.643	0.000	0.000	0.055	0.060	-0.066	8.348
	Midwest	0.0													
	South	40.9	-0.516	-0.149	-0.032	0.000	0.033	0.147	0.471	0.000	0.000	0.057	0.065	-0.071	6.305
	West	0.0													
	Unk.	0.0													

Table 44. L&R alignment (62-foot MCO) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	32.2	-1.090	-0.355	-0.059	0.000	0.059	0.349	1.324	0.000	0.000	0.123	0.118	0.092	10.868
	Concrete	34.6	-1.480	-0.585	-0.065	0.000	0.066	0.587	1.808	0.001	0.000	0.187	0.131	0.091	10.014
	Unk.	1.9													
3	Timber	4,422.3	-1.536	-0.365	-0.070	0.000	0.070	0.366	1.560	0.000	0.000	0.135	0.140	0.000	8.863
	Concrete	774.4	-1.589	-0.330	-0.053	0.000	0.054	0.328	1.580	0.000	0.000	0.117	0.107	-0.069	15.431
	Unk.	629.0	-1.541	-0.351	-0.061	0.000	0.061	0.352	1.737	0.000	0.000	0.126	0.121	0.003	11.346
4	Timber	16,706.0	-1.207	-0.285	-0.059	0.000	0.059	0.285	1.235	0.000	0.000	0.108	0.117	0.004	8.154
	Concrete	3,372.7	-1.136	-0.240	-0.046	0.000	0.046	0.239	1.177	0.000	0.000	0.089	0.092	0.011	10.789
	Unk.	2,554.7	-1.263	-0.270	-0.053	0.000	0.053	0.269	1.169	0.000	0.000	0.100	0.106	-0.026	9.098
5	Timber	5,070.2	-1.051	-0.243	-0.053	0.000	0.053	0.243	1.086	0.000	0.000	0.093	0.106	-0.003	7.319
	Concrete	1,009.6	-0.875	-0.181	-0.037	0.000	0.037	0.181	0.829	0.000	0.000	0.069	0.074	-0.019	10.571
	Unk.	671.7	-1.234	-0.215	-0.045	0.000	0.045	0.214	1.391	0.000	0.000	0.083	0.089	0.063	12.422
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-0.784	-0.209	-0.039	0.000	0.039	0.209	0.751	0.000	0.000	0.076	0.077	-0.014	9.301
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-0.939	-0.176	-0.035	0.000	0.035	0.174	0.870	0.000	0.000	0.066	0.070	-0.051	9.918
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.569	-0.148	-0.030	0.000	0.031	0.148	0.612	0.000	0.000	0.056	0.061	-0.067	7.775

Table 45. L&R alignment (62-foot MCO) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	4.4													
	Prim. Frgt.	62.4	-1.467	-0.516	-0.063	0.000	0.064	0.520	1.799	0.000	0.000	0.163	0.127	0.089	11.382
	Prim. Pass.	2.0													
3	Frgt. Only	3,225.2	-1.477	-0.349	-0.067	0.000	0.067	0.350	1.458	0.000	0.000	0.129	0.134	-0.011	8.762
	Prim. Frgt.	2,238.1	-1.649	-0.378	-0.066	0.000	0.066	0.377	1.719	0.000	0.000	0.136	0.133	0.003	10.680
	Prim. Pass.	362.4	-1.468	-0.351	-0.063	0.000	0.063	0.354	1.493	0.000	0.000	0.128	0.126	-0.030	10.371
4	Frgt. Only	10,104.3	-1.156	-0.278	-0.057	0.000	0.057	0.278	1.123	0.000	0.000	0.105	0.114	-0.002	7.791
	Prim. Frgt.	11,890.4	-1.253	-0.279	-0.055	0.000	0.055	0.278	1.289	0.000	0.000	0.104	0.111	0.003	9.267
	Prim. Pass.	638.7	-1.067	-0.260	-0.051	0.000	0.051	0.259	1.045	0.000	0.000	0.097	0.102	0.006	8.202
5	Frgt. Only	2,325.5	-0.881	-0.210	-0.044	0.000	0.044	0.209	0.896	0.000	0.000	0.080	0.088	0.001	8.030
	Prim. Frgt.	4,186.7	-1.139	-0.245	-0.053	0.000	0.053	0.246	1.225	0.000	0.000	0.094	0.106	0.003	7.824
	Prim. Pass.	239.3	-1.392	-0.233	-0.045	0.000	0.045	0.231	0.980	0.000	0.000	0.086	0.090	-0.059	10.013
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-0.784	-0.211	-0.039	0.000	0.039	0.212	0.751	0.000	0.000	0.077	0.078	-0.016	9.226
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-0.691	-0.175	-0.035	0.000	0.035	0.173	0.690	0.000	0.000	0.065	0.070	-0.044	8.424
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.569	-0.148	-0.030	0.000	0.031	0.148	0.612	0.000	0.000	0.056	0.061	-0.067	7.775

Left & Right Alignment (124-foot MCO)

Table 46. L&R alignment (124-foot MCO) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-3.311	-1.064	-0.099	0.000	0.100	1.150	3.373	0.002	0.000	0.334	0.199	0.030	25.629
3	5,521.8	-4.826	-1.522	-0.129	0.000	0.129	1.530	4.593	0.000	0.000	0.456	0.258	0.009	14.538
4	22,485.4	-3.610	-0.748	-0.094	0.000	0.094	0.751	3.664	0.000	0.000	0.246	0.188	0.015	19.618
5	6,722.9	-2.787	-0.404	-0.076	0.000	0.076	0.405	3.169	0.000	0.000	0.152	0.151	0.092	25.453
6	136.1	-1.251	-0.406	-0.067	0.000	0.066	0.418	1.463	0.000	0.000	0.143	0.133	0.102	7.912
7	186.6	-1.157	-0.325	-0.059	0.000	0.060	0.321	1.050	0.000	0.000	0.118	0.119	-0.062	8.146
8	158.1	-0.790	-0.243	-0.047	0.000	0.047	0.241	0.891	0.000	0.000	0.089	0.094	0.008	7.507

Table 47. L&R alignment (124-foot MCO) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-2.950	-0.562	-0.087	0.000	0.090	0.576	2.975	0.002	0.000	0.214	0.177	0.267	28.635
	Curved	9.3													
3	Tang.	3,381.9	-3.309	-0.748	-0.099	0.000	0.099	0.743	3.408	0.000	0.000	0.250	0.198	-0.029	19.330
	Curved	2,139.9	-5.157	-2.016	-0.227	0.000	0.227	2.022	4.949	0.001	0.000	0.662	0.455	0.008	7.835
4	Tang.	17,049.2	-2.301	-0.493	-0.084	0.000	0.084	0.490	2.235	0.000	0.000	0.175	0.168	-0.028	12.672
	Curved	5,436.2	-4.341	-1.159	-0.148	0.000	0.148	1.165	4.327	0.000	0.000	0.391	0.296	0.020	10.964
5	Tang.	5,562.2	-1.853	-0.368	-0.072	0.000	0.072	0.369	1.773	0.000	0.000	0.136	0.144	-0.025	9.431
	Curved	1,160.6	-3.102	-0.534	-0.096	0.000	0.096	0.534	4.333	0.000	0.000	0.212	0.192	0.231	31.461
6	Tang.	82.2	-1.121	-0.355	-0.058	0.000	0.057	0.368	1.141	0.000	0.000	0.123	0.115	0.136	10.063
	Curved	54.0	-1.322	-0.451	-0.086	0.000	0.087	0.467	1.485	0.001	0.000	0.169	0.172	0.069	5.936
7	Tang.	120.4	-0.927	-0.298	-0.056	0.000	0.056	0.291	1.023	0.000	0.000	0.108	0.112	-0.009	7.887
	Curved	66.2	-1.208	-0.362	-0.066	0.001	0.069	0.357	1.069	0.001	0.000	0.133	0.134	-0.118	7.746
8	Tang.	132.8	-0.797	-0.235	-0.045	0.000	0.046	0.231	0.903	0.000	0.000	0.086	0.091	-0.021	8.096
	Curved	25.3	-0.557	-0.271	-0.055	0.000	0.057	0.278	0.706	0.001	0.000	0.103	0.112	0.090	5.426

Table 48. L&R alignment (124-foot MCO) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-1.382	-0.447	-0.087	0.000	0.089	0.441	1.422	0.000	0.000	0.166	0.176	0.082	8.283
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-4.728	-1.327	-0.125	0.000	0.127	1.334	4.055	0.001	0.000	0.416	0.252	-0.048	13.644
	Midwest	1,274.7	-5.012	-1.117	-0.105	0.000	0.105	1.117	4.454	0.000	0.000	0.350	0.211	-0.012	23.149
	South	1,859.4	-4.865	-1.454	-0.138	0.000	0.138	1.458	4.676	0.000	0.000	0.444	0.275	-0.004	14.153
	West	1,727.3	-4.599	-1.817	-0.143	0.000	0.143	1.828	4.650	0.000	0.000	0.545	0.285	0.032	11.418
	Unk.	23.0	-5.519	-1.277	-0.115	-0.002	0.109	1.276	3.440	-0.008	0.000	0.414	0.224	-0.622	24.309
4	Northeast	1,020.6	-3.606	-0.621	-0.093	0.000	0.093	0.625	3.747	0.000	0.000	0.217	0.185	0.119	21.006
	Midwest	5,525.3	-3.040	-0.620	-0.088	0.000	0.089	0.622	3.055	0.000	0.000	0.209	0.177	0.017	16.743
	South	7,924.4	-3.972	-0.833	-0.103	0.000	0.103	0.833	3.882	0.000	0.000	0.273	0.207	0.017	19.909
	West	7,780.1	-3.303	-0.772	-0.091	0.000	0.091	0.778	3.577	0.000	0.000	0.245	0.182	0.005	17.538
	Unk.	235.0	-3.951	-0.532	-0.076	0.000	0.075	0.523	2.917	0.000	0.000	0.182	0.151	-0.321	30.795
5	Northeast	61.0	-2.720	-0.462	-0.063	0.000	0.063	0.467	3.489	0.000	0.000	0.161	0.126	-0.028	26.219
	Midwest	1,509.1	-2.894	-0.410	-0.069	0.000	0.069	0.412	3.219	0.000	0.000	0.148	0.137	0.152	28.095
	South	305.1	-1.828	-0.496	-0.079	0.000	0.080	0.487	1.564	0.000	0.000	0.169	0.159	-0.081	8.800
	West	4,657.7	-2.766	-0.395	-0.077	0.000	0.077	0.396	3.072	0.000	0.000	0.152	0.155	0.063	24.490
	Unk.	190.1	-3.206	-0.396	-0.079	0.000	0.079	0.393	4.486	0.000	0.000	0.159	0.157	0.697	60.427
6	Northeast	104.9	-1.024	-0.396	-0.065	0.000	0.064	0.411	1.067	0.000	0.000	0.140	0.130	0.109	7.631
	Midwest	2.1													
	South	24.9	-1.405	-0.446	-0.069	0.000	0.072	0.436	1.491	0.000	0.000	0.154	0.142	0.067	9.112
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.068	-0.318	-0.059	0.000	0.060	0.315	0.930	0.000	0.000	0.115	0.118	-0.083	7.141
	Midwest	0.0													
	South	103.1	-1.208	-0.328	-0.060	0.000	0.061	0.326	1.074	0.000	0.000	0.119	0.120	-0.034	8.623
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.805	-0.237	-0.045	0.000	0.046	0.238	0.712	0.000	0.000	0.087	0.091	-0.007	7.617
	Midwest	0.0													
	South	40.9	-0.672	-0.260	-0.051	0.000	0.052	0.249	0.984	0.000	0.000	0.095	0.104	0.040	7.132
	West	0.0													
	Unk.	0.0													

Table 49. L&R alignment (124-foot MCO) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-2.325	-0.780	-0.094	0.000	0.095	0.785	2.146	0.000	0.000	0.244	0.188	-0.030	17.140
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-4.803	-1.459	-0.134	0.000	0.134	1.458	4.620	0.000	0.000	0.441	0.267	0.003	14.897
	Concrete	724.6	-4.968	-1.697	-0.111	0.000	0.111	1.722	4.604	0.000	0.000	0.508	0.221	0.027	12.824
	Unk.	573.2	-4.740	-1.692	-0.117	0.000	0.117	1.726	4.365	0.001	0.000	0.498	0.234	0.013	13.805
4	Timber	16,606.0	-3.598	-0.735	-0.098	0.000	0.098	0.737	3.592	0.000	0.000	0.246	0.197	0.024	19.359
	Concrete	3,342.8	-3.348	-0.835	-0.081	0.000	0.080	0.835	3.845	0.000	0.000	0.251	0.161	0.015	17.604
	Unk.	2,536.6	-3.820	-0.713	-0.086	0.000	0.086	0.725	3.969	0.000	0.000	0.235	0.172	-0.050	24.864
5	Timber	5,052.1	-2.747	-0.407	-0.081	0.000	0.080	0.407	3.112	0.000	0.000	0.155	0.161	0.097	21.752
	Concrete	1,000.0	-2.162	-0.386	-0.058	0.000	0.058	0.391	2.051	0.000	0.000	0.132	0.115	-0.161	18.684
	Unk.	670.8	-3.064	-0.399	-0.069	0.000	0.069	0.402	4.151	0.000	0.000	0.156	0.138	0.282	55.334
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.253	-0.405	-0.066	0.000	0.066	0.415	1.464	0.000	0.000	0.142	0.132	0.100	8.062
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-1.157	-0.324	-0.059	0.000	0.060	0.321	1.051	0.000	0.000	0.117	0.119	-0.060	8.168
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.790	-0.243	-0.047	0.000	0.047	0.241	0.891	0.000	0.000	0.089	0.094	0.008	7.507

Table 50. L&R alignment (124-foot MCO) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-3.315	-0.966	-0.095	0.000	0.097	1.077	3.375	0.003	0.000	0.319	0.191	0.124	30.677
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-4.437	-1.282	-0.118	0.000	0.118	1.298	4.271	0.000	0.000	0.389	0.236	0.019	17.778
	Prim. Frgt.	2,090.9	-5.161	-1.757	-0.149	0.000	0.150	1.759	4.895	0.000	0.000	0.538	0.299	0.007	11.342
	Prim. Pass.	351.9	-4.790	-1.580	-0.130	0.000	0.130	1.556	4.576	-0.001	0.000	0.472	0.259	-0.031	13.652
4	Frgt. Only	10,050.2	-3.026	-0.658	-0.093	0.000	0.092	0.661	3.382	0.000	0.000	0.220	0.185	0.062	16.162
	Prim. Frgt.	11,799.6	-3.896	-0.824	-0.096	0.000	0.096	0.827	3.793	0.000	0.000	0.265	0.191	-0.008	20.189
	Prim. Pass.	635.6	-3.755	-0.739	-0.093	0.000	0.093	0.754	3.470	0.000	0.000	0.244	0.185	0.030	17.755
5	Frgt. Only	2,314.9	-2.328	-0.360	-0.065	0.000	0.065	0.362	2.113	0.000	0.000	0.130	0.130	-0.030	14.464
	Prim. Frgt.	4,171.3	-2.865	-0.418	-0.082	0.000	0.082	0.418	3.277	0.000	0.000	0.160	0.164	0.112	25.329
	Prim. Pass.	236.7	-3.249	-0.492	-0.079	0.000	0.079	0.496	4.544	0.000	0.000	0.190	0.158	0.249	37.676
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.253	-0.406	-0.066	0.000	0.066	0.417	1.464	0.000	0.000	0.143	0.132	0.099	7.975
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.157	-0.323	-0.059	0.000	0.060	0.320	1.051	0.000	0.000	0.117	0.119	-0.052	8.048
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.790	-0.243	-0.047	0.000	0.047	0.241	0.891	0.000	0.000	0.089	0.094	0.008	7.507

Mean Surface (Space Curve, Unfiltered)

Table 51. Mean surface (space curve, unfiltered) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-2.145	-0.754	-0.146	0.007	0.160	0.659	2.220	0.000	-0.024	0.273	0.306	-0.146	6.439
3	5,521.8	-2.987	-0.944	-0.170	0.005	0.176	0.895	3.075	0.000	-0.003	0.337	0.346	-0.082	6.902
4	22,485.4	-2.371	-0.746	-0.136	0.004	0.140	0.721	2.524	0.000	0.000	0.267	0.276	-0.033	7.076
5	6,722.9	-1.743	-0.620	-0.114	0.004	0.119	0.577	1.893	0.000	0.000	0.219	0.233	-0.146	6.601
6	136.1	-1.435	-0.596	-0.105	0.004	0.110	0.574	1.489	0.001	0.030	0.210	0.215	-0.119	6.186
7	186.6	-1.318	-0.572	-0.104	0.002	0.108	0.534	1.400	0.000	0.025	0.202	0.212	-0.086	6.056
8	158.1	-1.336	-0.420	-0.073	0.002	0.076	0.378	1.218	0.000	0.000	0.144	0.149	-0.210	7.308

Table 52. Mean surface (space curve, unfiltered) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-2.150	-0.750	-0.143	0.007	0.157	0.681	2.220	0.001	0.041	0.277	0.301	-0.107	6.715
	Curved	9.3													
3	Tang.	3,381.9	-2.768	-0.906	-0.158	0.007	0.167	0.865	2.866	0.001	0.039	0.321	0.325	-0.040	7.102
	Curved	2,139.9	-3.183	-0.999	-0.190	0.002	0.192	0.934	3.312	-0.002	-0.003	0.360	0.382	-0.124	6.524
4	Tang.	17,049.2	-2.375	-0.744	-0.133	0.005	0.138	0.720	2.589	0.001	0.000	0.265	0.272	-0.027	7.248
	Curved	5,436.2	-2.365	-0.750	-0.144	0.002	0.147	0.724	2.287	0.000	-0.011	0.273	0.291	-0.051	6.576
5	Tang.	5,562.2	-1.757	-0.625	-0.113	0.004	0.118	0.582	1.908	0.000	0.000	0.220	0.231	-0.145	6.699
	Curved	1,160.6	-1.663	-0.594	-0.116	0.005	0.124	0.553	1.838	0.001	0.005	0.216	0.241	-0.150	6.086
6	Tang.	82.2	-1.482	-0.616	-0.104	0.004	0.110	0.574	1.534	0.000	-0.025	0.212	0.214	-0.169	6.440
	Curved	54.0	-1.269	-0.570	-0.106	0.004	0.111	0.574	1.239	0.002	0.011	0.206	0.217	-0.033	5.728
7	Tang.	120.4	-1.321	-0.591	-0.110	0.002	0.112	0.556	1.406	0.000	0.025	0.209	0.222	-0.063	5.864
	Curved	66.2	-1.300	-0.543	-0.095	0.003	0.102	0.486	1.365	0.001	-0.015	0.188	0.197	-0.139	6.372
8	Tang.	132.8	-1.343	-0.424	-0.073	0.001	0.075	0.379	1.219	-0.001	0.000	0.144	0.147	-0.199	7.601
	Curved	25.3	-1.079	-0.398	-0.075	0.004	0.086	0.375	0.701	0.004	-0.004	0.143	0.161	-0.267	5.754

Table 53. Mean surface (space curve, unfiltered) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-2.149	-0.744	-0.149	0.005	0.161	0.648	2.220	-0.001	0.017	0.274	0.310	-0.108	6.957
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-3.039	-0.872	-0.141	0.006	0.150	0.797	2.819	0.000	0.011	0.300	0.291	-0.321	8.717
	Midwest	1,274.7	-2.486	-0.933	-0.160	0.004	0.164	0.912	3.232	0.000	-0.003	0.330	0.324	0.067	7.478
	South	1,859.4	-3.206	-1.013	-0.190	0.007	0.197	0.967	3.203	0.000	0.039	0.367	0.387	-0.066	6.488
	West	1,727.3	-2.800	-0.889	-0.168	0.005	0.175	0.837	2.820	0.000	0.006	0.321	0.343	-0.148	6.146
	Unk.	23.0	-2.972	-0.911	-0.155	0.011	0.167	0.824	1.871	-0.002	0.076	0.317	0.322	-0.323	7.054
4	Northeast	1,020.6	-2.519	-0.646	-0.111	0.004	0.117	0.610	2.321	0.000	0.025	0.227	0.229	-0.279	8.304
	Midwest	5,525.3	-2.318	-0.761	-0.140	0.004	0.143	0.752	2.588	0.000	0.014	0.275	0.284	0.047	7.147
	South	7,924.4	-2.567	-0.793	-0.142	0.004	0.147	0.761	2.688	0.000	-0.011	0.282	0.289	-0.052	7.100
	West	7,780.1	-2.143	-0.694	-0.131	0.004	0.136	0.672	2.069	0.001	0.000	0.251	0.267	-0.056	6.437
	Unk.	235.0	-2.080	-0.641	-0.113	0.004	0.118	0.605	2.896	0.000	-0.025	0.227	0.231	-0.068	8.928
5	Northeast	61.0	-1.490	-0.648	-0.109	0.002	0.111	0.607	1.895	0.000	0.019	0.218	0.220	-0.003	7.513
	Midwest	1,509.1	-1.787	-0.637	-0.114	0.003	0.117	0.623	2.254	0.000	0.025	0.227	0.231	-0.002	6.969
	South	305.1	-1.989	-0.749	-0.127	0.004	0.133	0.705	2.054	0.000	0.008	0.259	0.260	-0.078	6.999
	West	4,657.7	-1.701	-0.601	-0.112	0.005	0.118	0.551	1.741	0.000	0.000	0.212	0.231	-0.207	6.312
	Unk.	190.1	-1.763	-0.671	-0.130	0.008	0.140	0.599	1.804	0.000	0.048	0.239	0.270	-0.233	5.545
6	Northeast	104.9	-1.328	-0.587	-0.103	0.003	0.108	0.561	1.323	0.001	0.030	0.206	0.211	-0.116	6.095
	Midwest	2.1													
	South	24.9	-1.526	-0.618	-0.108	0.005	0.116	0.627	1.168	0.002	0.039	0.220	0.223	-0.154	6.344
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.310	-0.581	-0.103	0.001	0.104	0.561	1.402	0.000	0.000	0.204	0.206	-0.001	6.457
	Midwest	0.0													
	South	103.1	-1.327	-0.565	-0.105	0.003	0.112	0.512	1.375	0.000	0.025	0.200	0.217	-0.163	5.694
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-1.346	-0.420	-0.072	0.001	0.074	0.383	1.220	0.000	0.000	0.143	0.145	-0.134	7.971
	Midwest	0.0													
	South	40.9	-1.084	-0.420	-0.078	0.004	0.084	0.368	0.673	0.000	-0.006	0.146	0.162	-0.416	5.542
	West	0.0													
	Unk.	0.0													

Table 54. Mean surface (space curve, unfiltered) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-2.147	-0.749	-0.145	0.007	0.159	0.671	2.220	0.001	0.017	0.274	0.304	-0.094	6.757
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-3.051	-0.969	-0.177	0.007	0.184	0.916	3.137	0.000	0.039	0.346	0.361	-0.081	6.740
	Concrete	724.6	-2.930	-0.860	-0.148	0.002	0.150	0.825	2.770	-0.001	-0.003	0.303	0.298	-0.080	7.253
	Unk.	573.2	-2.730	-0.838	-0.149	0.003	0.154	0.819	2.904	0.000	0.011	0.302	0.303	-0.092	7.360
4	Timber	16,606.0	-2.426	-0.771	-0.142	0.005	0.148	0.743	2.562	0.001	0.000	0.277	0.290	-0.040	6.846
	Concrete	3,342.8	-2.077	-0.652	-0.119	0.001	0.118	0.645	2.311	-0.001	0.000	0.233	0.237	0.038	7.479
	Unk.	2,536.6	-2.311	-0.669	-0.123	0.003	0.126	0.653	2.399	0.000	0.011	0.240	0.248	-0.061	7.664
5	Timber	5,052.1	-1.747	-0.641	-0.119	0.005	0.125	0.591	1.871	0.000	0.000	0.226	0.244	-0.173	6.309
	Concrete	1,000.0	-1.761	-0.520	-0.096	0.000	0.095	0.516	2.243	-0.001	0.025	0.188	0.191	0.095	8.588
	Unk.	670.8	-1.678	-0.579	-0.107	0.003	0.112	0.542	1.748	0.000	-0.005	0.205	0.219	-0.146	6.469
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.438	-0.593	-0.104	0.004	0.109	0.572	1.318	0.001	0.011	0.208	0.213	-0.122	6.179
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-1.318	-0.573	-0.104	0.002	0.108	0.535	1.400	0.000	0.025	0.202	0.212	-0.086	6.059
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-1.336	-0.420	-0.073	0.002	0.076	0.378	1.218	0.000	0.000	0.144	0.149	-0.210	7.308

Table 55. Mean surface (space curve, unfiltered) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-2.147	-0.771	-0.145	0.007	0.160	0.652	2.220	0.000	-0.024	0.274	0.305	-0.201	6.623
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-3.057	-0.967	-0.173	0.006	0.180	0.926	3.171	0.000	-0.003	0.345	0.354	-0.006	6.978
	Prim. Frgt.	2,090.9	-2.867	-0.916	-0.168	0.005	0.175	0.865	2.718	0.000	-0.025	0.328	0.343	-0.186	6.510
	Prim. Pass.	351.9	-3.058	-0.885	-0.147	0.006	0.155	0.815	2.969	0.000	-0.028	0.309	0.302	-0.264	8.221
4	Frgt. Only	10,050.2	-2.292	-0.784	-0.146	0.004	0.151	0.768	2.625	0.000	0.000	0.284	0.297	0.029	6.802
	Prim. Frgt.	11,799.6	-2.474	-0.710	-0.128	0.004	0.133	0.683	2.291	0.000	0.000	0.253	0.261	-0.100	7.211
	Prim. Pass.	635.6	-2.373	-0.706	-0.125	0.004	0.131	0.660	2.563	0.000	0.016	0.249	0.257	-0.217	7.127
5	Frgt. Only	2,314.9	-1.742	-0.581	-0.104	0.003	0.108	0.558	2.029	0.000	0.011	0.205	0.212	-0.072	7.327
	Prim. Frgt.	4,171.3	-1.753	-0.641	-0.120	0.005	0.127	0.587	1.865	0.000	0.016	0.227	0.247	-0.175	6.233
	Prim. Pass.	236.7	-1.600	-0.582	-0.104	0.003	0.108	0.561	1.819	0.000	0.014	0.204	0.212	-0.145	6.995
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.437	-0.595	-0.104	0.004	0.109	0.574	1.318	0.001	0.030	0.209	0.214	-0.122	6.155
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.318	-0.572	-0.104	0.002	0.108	0.534	1.400	0.000	0.025	0.202	0.212	-0.088	6.056
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-1.336	-0.420	-0.073	0.002	0.076	0.378	1.218	0.000	0.000	0.144	0.149	-0.210	7.308

Mean Surface (Space Curve, 200-foot Filter)

Table 56. Mean surface (space curve, 200-foot filter) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-1.228	-0.379	-0.062	0.005	0.069	0.324	0.974	0.000	0.047	0.128	0.131	-0.553	9.416
3	5,521.8	-1.495	-0.434	-0.066	0.005	0.073	0.367	1.247	0.000	0.076	0.143	0.139	-0.534	8.637
4	22,485.4	-1.341	-0.369	-0.058	0.004	0.063	0.318	1.092	0.000	0.063	0.123	0.121	-0.522	8.902
5	6,722.9	-1.130	-0.318	-0.051	0.003	0.056	0.271	0.904	0.000	-0.042	0.107	0.107	-0.546	8.391
6	136.1	-0.994	-0.307	-0.035	0.004	0.042	0.235	0.860	0.000	-0.034	0.090	0.076	-1.011	12.130
7	186.6	-0.980	-0.272	-0.033	0.003	0.038	0.207	0.711	0.000	-0.104	0.081	0.071	-1.160	13.300
8	158.1	-0.746	-0.202	-0.027	0.002	0.031	0.155	0.440	0.000	-0.067	0.062	0.057	-1.233	13.315

Table 57. Mean surface (space curve, 200-foot filter) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-1.228	-0.382	-0.063	0.004	0.069	0.334	0.975	0.000	-0.183	0.130	0.132	-0.482	9.752
	Curved	9.3													
3	Tang.	3,381.9	-1.503	-0.456	-0.068	0.005	0.077	0.384	1.272	0.000	-0.111	0.150	0.145	-0.533	8.342
	Curved	2,139.9	-1.462	-0.394	-0.062	0.004	0.068	0.336	1.191	0.000	-0.074	0.131	0.129	-0.528	8.946
4	Tang.	17,049.2	-1.373	-0.382	-0.060	0.004	0.065	0.327	1.102	0.000	-0.066	0.127	0.125	-0.525	8.728
	Curved	5,436.2	-1.220	-0.323	-0.052	0.003	0.056	0.281	1.029	0.000	0.035	0.109	0.109	-0.489	9.065
5	Tang.	5,562.2	-1.144	-0.326	-0.052	0.004	0.057	0.277	0.922	0.000	0.044	0.109	0.109	-0.544	8.365
	Curved	1,160.6	-1.031	-0.279	-0.047	0.003	0.052	0.238	0.745	0.000	0.094	0.096	0.099	-0.539	7.977
6	Tang.	82.2	-1.177	-0.331	-0.037	0.004	0.044	0.252	0.920	0.000	-0.034	0.097	0.081	-1.023	11.592
	Curved	54.0	-0.864	-0.262	-0.032	0.002	0.038	0.206	0.663	0.000	-0.133	0.079	0.070	-0.927	12.171
7	Tang.	120.4	-1.027	-0.283	-0.034	0.003	0.040	0.216	0.741	0.000	-0.097	0.085	0.074	-1.113	12.930
	Curved	66.2	-0.883	-0.250	-0.030	0.003	0.035	0.185	0.502	0.000	-0.293	0.074	0.066	-1.266	13.599
8	Tang.	132.8	-0.752	-0.207	-0.027	0.002	0.031	0.157	0.447	0.000	-0.067	0.063	0.058	-1.219	12.978
	Curved	25.3	-0.734	-0.176	-0.026	0.002	0.029	0.145	0.413	0.000	-0.119	0.058	0.055	-1.316	15.407

Table 58. Mean surface (space curve, 200-foot filter) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-1.228	-0.384	-0.064	0.006	0.072	0.312	0.975	0.000	-0.206	0.131	0.136	-0.623	9.640
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-1.444	-0.384	-0.057	0.004	0.063	0.325	1.275	0.000	-0.122	0.125	0.119	-0.664	11.164
	Midwest	1,274.7	-1.445	-0.456	-0.066	0.005	0.074	0.386	1.281	0.000	0.064	0.149	0.140	-0.483	8.123
	South	1,859.4	-1.567	-0.457	-0.071	0.006	0.080	0.383	1.211	0.000	-0.063	0.151	0.151	-0.560	8.299
	West	1,727.3	-1.439	-0.403	-0.064	0.004	0.070	0.346	1.220	0.000	-0.142	0.135	0.133	-0.494	8.493
	Unk.	23.0	-1.361	-0.431	-0.057	0.005	0.064	0.364	0.897	0.000	-0.538	0.135	0.122	-0.608	9.419
4	Northeast	1,020.6	-1.307	-0.324	-0.052	0.003	0.057	0.277	0.996	0.000	-0.077	0.108	0.109	-0.618	10.720
	Midwest	5,525.3	-1.344	-0.391	-0.061	0.004	0.067	0.335	1.115	0.000	-0.126	0.130	0.127	-0.510	8.517
	South	7,924.4	-1.369	-0.376	-0.059	0.004	0.065	0.319	1.138	0.000	0.032	0.125	0.123	-0.558	9.125
	West	7,780.1	-1.301	-0.351	-0.055	0.003	0.060	0.307	1.032	0.000	0.071	0.118	0.116	-0.469	8.547
	Unk.	235.0	-1.373	-0.350	-0.052	0.003	0.057	0.296	1.035	0.000	-0.140	0.115	0.109	-0.722	10.805
5	Northeast	61.0	-1.030	-0.303	-0.033	0.002	0.037	0.249	0.712	0.000	0.032	0.090	0.070	-1.096	14.905
	Midwest	1,509.1	-1.255	-0.335	-0.045	0.003	0.051	0.284	1.006	0.000	-0.076	0.107	0.096	-0.659	10.781
	South	305.1	-1.229	-0.356	-0.055	0.003	0.060	0.311	0.926	0.000	-0.263	0.118	0.116	-0.453	8.275
	West	4,657.7	-1.045	-0.308	-0.053	0.003	0.058	0.263	0.828	0.000	-0.084	0.105	0.111	-0.499	7.502
	Unk.	190.1	-1.105	-0.370	-0.057	0.006	0.066	0.285	0.979	0.000	-0.268	0.118	0.123	-0.740	7.979
6	Northeast	104.9	-0.870	-0.296	-0.034	0.003	0.040	0.228	0.719	0.000	-0.034	0.087	0.074	-1.066	12.468
	Midwest	2.1													
	South	24.9	-1.271	-0.319	-0.034	0.004	0.043	0.238	0.620	0.000	-0.294	0.093	0.078	-1.174	12.509
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-0.887	-0.250	-0.034	0.002	0.038	0.208	0.607	0.000	-0.097	0.079	0.073	-0.786	10.825
	Midwest	0.0													
	South	103.1	-1.041	-0.287	-0.031	0.004	0.038	0.205	0.683	0.000	0.035	0.083	0.069	-1.440	14.686
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.724	-0.199	-0.026	0.002	0.030	0.156	0.440	0.000	-0.067	0.061	0.057	-1.156	12.832
	Midwest	0.0													
	South	40.9	-0.809	-0.211	-0.028	0.002	0.032	0.154	0.443	0.000	-0.119	0.064	0.060	-1.428	14.450
	West	0.0													
	Unk.	0.0													

Table 59. Mean surface (space curve, 200-foot filter) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-1.228	-0.382	-0.064	0.005	0.070	0.326	0.975	0.000	-0.206	0.130	0.134	-0.534	9.328
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-1.508	-0.449	-0.072	0.005	0.080	0.380	1.265	0.000	-0.135	0.150	0.152	-0.500	8.016
	Concrete	724.6	-1.390	-0.361	-0.045	0.004	0.051	0.298	1.090	0.000	-0.093	0.112	0.096	-0.752	12.192
	Unk.	573.2	-1.409	-0.384	-0.053	0.003	0.059	0.325	1.170	0.000	-0.066	0.124	0.112	-0.662	10.514
4	Timber	16,606.0	-1.356	-0.383	-0.064	0.004	0.070	0.330	1.115	0.000	0.067	0.130	0.134	-0.479	8.118
	Concrete	3,342.8	-1.263	-0.305	-0.039	0.003	0.043	0.259	0.987	0.000	-0.044	0.096	0.082	-0.767	13.855
	Unk.	2,536.6	-1.326	-0.336	-0.049	0.004	0.054	0.285	0.967	0.000	-0.071	0.110	0.103	-0.671	10.515
5	Timber	5,052.1	-1.099	-0.329	-0.057	0.004	0.063	0.279	0.917	0.000	0.044	0.112	0.120	-0.494	7.418
	Concrete	1,000.0	-1.256	-0.244	-0.032	0.002	0.035	0.217	0.857	0.000	0.034	0.079	0.067	-0.964	19.400
	Unk.	670.8	-1.045	-0.304	-0.045	0.003	0.051	0.250	0.831	0.000	-0.018	0.099	0.096	-0.684	9.152
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.008	-0.303	-0.034	0.004	0.041	0.230	0.695	0.000	-0.034	0.089	0.075	-1.090	12.499
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-0.980	-0.272	-0.033	0.003	0.038	0.207	0.711	0.000	-0.104	0.081	0.071	-1.162	13.321
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.746	-0.202	-0.027	0.002	0.031	0.155	0.440	0.000	-0.067	0.062	0.057	-1.233	13.315

Table 60. Mean surface (space curve, 200-foot filter) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-1.228	-0.375	-0.061	0.005	0.069	0.308	0.971	0.000	0.047	0.126	0.129	-0.690	9.649
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-1.517	-0.460	-0.071	0.005	0.079	0.386	1.261	0.000	-0.063	0.152	0.150	-0.529	8.060
	Prim. Frgt.	2,090.9	-1.462	-0.393	-0.061	0.004	0.067	0.340	1.220	0.000	-0.085	0.131	0.128	-0.505	9.116
	Prim. Pass.	351.9	-1.384	-0.403	-0.054	0.004	0.061	0.333	1.179	0.000	-0.369	0.127	0.115	-0.695	11.014
4	Frgt. Only	10,050.2	-1.395	-0.397	-0.062	0.004	0.068	0.340	1.119	0.000	0.079	0.132	0.130	-0.503	8.253
	Prim. Frgt.	11,799.6	-1.287	-0.342	-0.055	0.003	0.060	0.296	1.060	0.000	-0.070	0.115	0.114	-0.529	9.328
	Prim. Pass.	635.6	-1.313	-0.355	-0.050	0.003	0.056	0.294	0.999	0.000	-0.151	0.113	0.106	-0.678	10.597
5	Frgt. Only	2,314.9	-1.231	-0.312	-0.044	0.003	0.049	0.268	0.931	0.000	-0.067	0.101	0.093	-0.639	10.423
	Prim. Frgt.	4,171.3	-1.072	-0.323	-0.056	0.004	0.062	0.274	0.885	0.000	-0.046	0.110	0.118	-0.499	7.432
	Prim. Pass.	236.7	-0.971	-0.273	-0.040	0.003	0.044	0.229	0.872	0.000	-0.185	0.089	0.084	-0.664	10.063
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.006	-0.305	-0.034	0.004	0.041	0.232	0.695	0.000	-0.034	0.089	0.075	-1.082	12.469
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-0.980	-0.271	-0.033	0.003	0.038	0.207	0.665	0.000	-0.104	0.081	0.071	-1.171	13.176
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.746	-0.202	-0.027	0.002	0.031	0.155	0.440	0.000	-0.067	0.062	0.057	-1.233	13.315

Left & Right Surface (Space Curve, Unfiltered)

Table 61. L&R surface (space curve, unfiltered) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-2.149	-0.764	-0.148	0.008	0.164	0.675	2.241	0.000	0.000	0.279	0.313	-0.149	6.354
3	5,521.8	-3.040	-0.963	-0.173	0.006	0.180	0.910	3.086	0.000	0.000	0.343	0.353	-0.095	6.817
4	22,485.4	-2.414	-0.760	-0.139	0.004	0.143	0.732	2.537	0.000	0.000	0.272	0.282	-0.047	7.008
5	6,722.9	-1.798	-0.630	-0.116	0.004	0.121	0.586	1.908	0.000	0.000	0.223	0.237	-0.158	6.602
6	136.1	-1.480	-0.609	-0.108	0.004	0.114	0.584	1.481	0.001	0.000	0.214	0.221	-0.136	6.233
7	186.6	-1.381	-0.583	-0.107	0.002	0.111	0.540	1.418	0.000	0.000	0.206	0.218	-0.102	6.026
8	158.1	-1.330	-0.428	-0.075	0.002	0.078	0.385	1.298	0.000	0.000	0.147	0.153	-0.227	7.310

Table 62. L&R surface (space curve, unfiltered) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-2.160	-0.761	-0.146	0.007	0.160	0.700	2.245	0.001	0.000	0.282	0.306	-0.107	6.618
	Curved	9.3													
3	Tang.	3,381.9	-2.780	-0.924	-0.161	0.008	0.171	0.877	2.894	0.001	0.000	0.327	0.331	-0.061	7.028
	Curved	2,139.9	-3.217	-1.021	-0.194	0.002	0.197	0.953	3.319	-0.002	0.000	0.367	0.391	-0.129	6.425
4	Tang.	17,049.2	-2.405	-0.757	-0.135	0.005	0.141	0.730	2.599	0.001	0.000	0.269	0.276	-0.042	7.192
	Curved	5,436.2	-2.435	-0.768	-0.148	0.002	0.151	0.740	2.334	0.000	0.000	0.279	0.299	-0.060	6.481
5	Tang.	5,562.2	-1.805	-0.634	-0.115	0.004	0.120	0.590	1.925	0.000	0.000	0.223	0.235	-0.155	6.696
	Curved	1,160.6	-1.749	-0.610	-0.119	0.005	0.128	0.566	1.842	0.001	0.000	0.221	0.247	-0.168	6.130
6	Tang.	82.2	-1.655	-0.629	-0.106	0.004	0.112	0.581	1.518	0.000	0.000	0.216	0.218	-0.191	6.553
	Curved	54.0	-1.431	-0.583	-0.110	0.004	0.116	0.587	1.396	0.002	0.000	0.211	0.226	-0.046	5.693
7	Tang.	120.4	-1.380	-0.600	-0.111	0.002	0.114	0.562	1.426	0.000	0.000	0.212	0.225	-0.078	5.864
	Curved	66.2	-1.390	-0.554	-0.099	0.003	0.107	0.499	1.399	0.001	0.000	0.194	0.206	-0.155	6.297
8	Tang.	132.8	-1.342	-0.431	-0.074	0.002	0.076	0.384	1.333	-0.001	0.000	0.146	0.150	-0.218	7.656
	Curved	25.3	-1.133	-0.408	-0.079	0.004	0.090	0.387	0.742	0.004	0.000	0.149	0.169	-0.277	5.632

Table 63. L&R surface (space curve, unfiltered) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-2.158	-0.755	-0.152	0.006	0.164	0.663	2.244	-0.001	0.000	0.279	0.316	-0.125	6.802
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-3.118	-0.890	-0.146	0.007	0.155	0.810	2.811	0.000	0.000	0.307	0.300	-0.327	8.594
	Midwest	1,274.7	-2.551	-0.950	-0.163	0.004	0.168	0.925	3.253	0.000	0.000	0.336	0.331	0.046	7.372
	South	1,859.4	-3.209	-1.034	-0.193	0.008	0.201	0.981	3.204	0.000	0.000	0.373	0.394	-0.081	6.420
	West	1,727.3	-2.843	-0.909	-0.172	0.005	0.179	0.856	2.815	0.000	0.000	0.328	0.351	-0.154	6.087
	Unk.	23.0	-3.099	-0.936	-0.158	0.010	0.172	0.831	2.124	-0.002	0.000	0.323	0.329	-0.324	7.057
4	Northeast	1,020.6	-2.537	-0.659	-0.114	0.004	0.121	0.621	2.393	0.000	0.000	0.231	0.235	-0.286	8.171
	Midwest	5,525.3	-2.387	-0.774	-0.142	0.004	0.146	0.762	2.609	0.000	0.000	0.280	0.288	0.030	7.087
	South	7,924.4	-2.602	-0.808	-0.145	0.004	0.150	0.772	2.703	0.000	0.000	0.287	0.295	-0.065	7.032
	West	7,780.1	-2.181	-0.708	-0.134	0.004	0.139	0.684	2.088	0.001	0.000	0.256	0.273	-0.067	6.392
	Unk.	235.0	-2.159	-0.653	-0.115	0.004	0.121	0.614	2.899	0.000	0.000	0.231	0.236	-0.085	8.825
5	Northeast	61.0	-1.596	-0.657	-0.111	0.002	0.114	0.615	1.977	0.000	0.000	0.223	0.226	-0.024	7.364
	Midwest	1,509.1	-1.845	-0.647	-0.116	0.003	0.119	0.632	2.271	0.000	0.000	0.231	0.235	-0.020	6.970
	South	305.1	-2.022	-0.760	-0.129	0.004	0.135	0.719	2.098	0.000	0.000	0.263	0.264	-0.090	6.995
	West	4,657.7	-1.754	-0.611	-0.114	0.005	0.121	0.560	1.753	0.000	0.000	0.216	0.235	-0.215	6.315
	Unk.	190.1	-1.801	-0.684	-0.132	0.008	0.142	0.609	1.810	0.000	0.000	0.243	0.273	-0.255	5.592
6	Northeast	104.9	-1.424	-0.598	-0.106	0.003	0.111	0.570	1.429	0.001	0.000	0.210	0.217	-0.131	6.136
	Midwest	2.1													
	South	24.9	-1.838	-0.638	-0.111	0.005	0.118	0.635	1.298	0.002	0.000	0.225	0.229	-0.178	6.434
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.309	-0.589	-0.105	0.002	0.106	0.565	1.426	0.000	0.000	0.207	0.211	-0.011	6.387
	Midwest	0.0													
	South	103.1	-1.403	-0.577	-0.108	0.003	0.115	0.519	1.401	0.000	0.000	0.204	0.223	-0.183	5.707
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-1.348	-0.425	-0.073	0.001	0.075	0.388	1.352	0.000	0.000	0.146	0.148	-0.145	7.947
	Midwest	0.0													
	South	40.9	-1.120	-0.435	-0.080	0.004	0.087	0.377	0.729	0.000	0.000	0.150	0.167	-0.444	5.674
	West	0.0													
	Unk.	0.0													

Table 64. L&R surface (space curve, unfiltered) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-2.151	-0.760	-0.148	0.007	0.162	0.687	2.242	0.001	0.000	0.279	0.310	-0.102	6.659
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-3.080	-0.989	-0.180	0.007	0.189	0.931	3.151	0.000	0.000	0.353	0.369	-0.096	6.653
	Concrete	724.6	-3.003	-0.872	-0.150	0.002	0.153	0.837	2.804	-0.001	0.000	0.308	0.303	-0.084	7.182
	Unk.	573.2	-2.767	-0.859	-0.153	0.003	0.157	0.836	2.837	0.000	0.000	0.308	0.309	-0.102	7.285
4	Timber	16,606.0	-2.475	-0.786	-0.145	0.005	0.151	0.755	2.580	0.001	0.000	0.282	0.295	-0.053	6.784
	Concrete	3,342.8	-2.112	-0.664	-0.121	0.001	0.121	0.655	2.344	-0.001	0.000	0.238	0.242	0.024	7.405
	Unk.	2,536.6	-2.328	-0.683	-0.125	0.003	0.128	0.663	2.440	0.000	0.000	0.245	0.254	-0.074	7.558
5	Timber	5,052.1	-1.809	-0.652	-0.121	0.005	0.128	0.599	1.887	0.000	0.000	0.230	0.249	-0.183	6.317
	Concrete	1,000.0	-1.798	-0.529	-0.098	0.000	0.097	0.526	2.255	-0.001	0.000	0.191	0.195	0.079	8.529
	Unk.	670.8	-1.736	-0.591	-0.109	0.003	0.114	0.551	1.744	0.000	0.000	0.209	0.224	-0.162	6.462
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.486	-0.607	-0.107	0.004	0.112	0.582	1.425	0.001	0.000	0.213	0.219	-0.140	6.233
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-1.381	-0.583	-0.107	0.002	0.111	0.540	1.418	0.000	0.000	0.206	0.218	-0.102	6.028
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-1.330	-0.428	-0.075	0.002	0.078	0.385	1.298	0.000	0.000	0.147	0.153	-0.227	7.310

Table 65. L&R surface (space curve, unfiltered) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-2.150	-0.782	-0.148	0.008	0.164	0.668	2.242	0.000	0.000	0.279	0.312	-0.210	6.496
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-3.076	-0.985	-0.177	0.006	0.184	0.939	3.192	0.000	0.000	0.351	0.361	-0.025	6.889
	Prim. Frgt.	2,090.9	-2.928	-0.937	-0.172	0.005	0.179	0.882	2.708	0.000	0.000	0.335	0.350	-0.190	6.455
	Prim. Pass.	351.9	-3.265	-0.904	-0.152	0.006	0.160	0.834	2.974	0.000	0.000	0.316	0.312	-0.267	8.054
4	Frgt. Only	10,050.2	-2.345	-0.798	-0.149	0.004	0.154	0.778	2.641	0.000	0.000	0.289	0.302	0.013	6.748
	Prim. Frgt.	11,799.6	-2.511	-0.724	-0.131	0.004	0.136	0.694	2.324	0.000	0.000	0.258	0.267	-0.110	7.138
	Prim. Pass.	635.6	-2.393	-0.723	-0.128	0.004	0.135	0.672	2.557	0.000	0.000	0.254	0.263	-0.222	7.011
5	Frgt. Only	2,314.9	-1.802	-0.591	-0.106	0.002	0.110	0.567	2.051	0.000	0.000	0.209	0.215	-0.085	7.328
	Prim. Frgt.	4,171.3	-1.801	-0.652	-0.122	0.005	0.129	0.596	1.869	0.000	0.000	0.231	0.251	-0.187	6.239
	Prim. Pass.	236.7	-1.608	-0.593	-0.107	0.004	0.111	0.569	1.779	0.000	0.000	0.209	0.218	-0.152	6.867
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.485	-0.608	-0.107	0.004	0.113	0.584	1.425	0.001	0.000	0.213	0.219	-0.139	6.210
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.381	-0.583	-0.107	0.002	0.111	0.540	1.418	0.000	0.000	0.206	0.218	-0.104	6.026
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-1.330	-0.428	-0.075	0.002	0.078	0.385	1.298	0.000	0.000	0.147	0.153	-0.227	7.310

Left & Right Surface (Space Curve, 200-foot Filter)

Table 66. L&R surface (space curve, 200-foot filter) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-1.260	-0.398	-0.065	0.005	0.072	0.341	1.020	0.000	0.043	0.134	0.136	-0.517	9.078
3	5,521.8	-1.574	-0.454	-0.069	0.005	0.077	0.383	1.269	0.000	0.064	0.149	0.145	-0.558	8.619
4	22,485.4	-1.385	-0.383	-0.060	0.004	0.066	0.329	1.111	0.000	0.063	0.128	0.126	-0.525	8.801
5	6,722.9	-1.170	-0.328	-0.053	0.004	0.059	0.280	0.924	0.000	0.064	0.110	0.112	-0.541	8.345
6	136.1	-1.127	-0.320	-0.037	0.004	0.044	0.247	0.899	0.000	0.031	0.095	0.082	-1.029	12.293
7	186.6	-1.089	-0.282	-0.035	0.003	0.041	0.215	0.728	0.000	0.035	0.085	0.076	-1.157	13.277
8	158.1	-0.813	-0.211	-0.029	0.002	0.033	0.163	0.469	0.000	-0.072	0.066	0.062	-1.227	13.264

Table 67. L&R surface (space curve, 200-foot filter) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-1.260	-0.401	-0.066	0.004	0.072	0.351	1.043	0.000	-0.017	0.135	0.137	-0.443	9.302
	Curved	9.3													
3	Tang.	3,381.9	-1.597	-0.477	-0.071	0.005	0.080	0.400	1.287	0.000	-0.138	0.156	0.152	-0.564	8.365
	Curved	2,139.9	-1.523	-0.414	-0.065	0.004	0.071	0.353	1.212	0.000	-0.079	0.138	0.136	-0.534	8.854
4	Tang.	17,049.2	-1.411	-0.395	-0.062	0.004	0.068	0.338	1.125	0.000	0.063	0.131	0.130	-0.529	8.651
	Curved	5,436.2	-1.275	-0.338	-0.055	0.003	0.060	0.295	1.048	0.000	0.036	0.114	0.115	-0.489	8.942
5	Tang.	5,562.2	-1.183	-0.335	-0.054	0.004	0.060	0.286	0.939	0.000	0.064	0.112	0.114	-0.540	8.319
	Curved	1,160.6	-1.116	-0.292	-0.050	0.003	0.055	0.250	0.779	0.000	0.069	0.100	0.104	-0.539	8.069
6	Tang.	82.2	-1.188	-0.347	-0.039	0.004	0.047	0.262	0.928	0.000	0.031	0.101	0.086	-1.044	11.773
	Curved	54.0	-0.940	-0.273	-0.035	0.003	0.040	0.218	0.654	0.000	-0.038	0.084	0.075	-0.948	12.449
7	Tang.	120.4	-1.103	-0.293	-0.036	0.003	0.043	0.225	0.747	0.000	-0.087	0.089	0.079	-1.116	12.917
	Curved	66.2	-1.049	-0.261	-0.033	0.003	0.038	0.196	0.591	0.000	-0.079	0.078	0.071	-1.247	13.680
8	Tang.	132.8	-0.818	-0.215	-0.029	0.002	0.033	0.165	0.475	0.000	-0.072	0.066	0.062	-1.212	12.961
	Curved	25.3	-0.785	-0.190	-0.028	0.002	0.032	0.155	0.445	0.000	-0.024	0.063	0.060	-1.313	15.092

Table 68. L&R surface (space curve, 200-foot filter) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-1.264	-0.403	-0.067	0.006	0.075	0.334	1.041	0.000	0.069	0.136	0.142	-0.593	9.154
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-1.490	-0.404	-0.060	0.004	0.066	0.341	1.311	0.000	-0.136	0.131	0.126	-0.660	10.877
	Midwest	1,274.7	-1.514	-0.475	-0.069	0.005	0.078	0.401	1.322	0.000	-0.153	0.156	0.147	-0.506	8.110
	South	1,859.4	-1.650	-0.480	-0.075	0.006	0.083	0.401	1.239	0.000	-0.130	0.158	0.158	-0.592	8.341
	West	1,727.3	-1.494	-0.422	-0.067	0.004	0.073	0.362	1.233	0.000	-0.144	0.141	0.140	-0.511	8.439
	Unk.	23.0	-1.373	-0.448	-0.060	0.005	0.067	0.377	1.016	0.000	-0.313	0.141	0.127	-0.635	9.493
4	Northeast	1,020.6	-1.351	-0.337	-0.055	0.003	0.059	0.289	1.025	0.000	-0.144	0.113	0.114	-0.632	10.577
	Midwest	5,525.3	-1.404	-0.403	-0.063	0.004	0.069	0.346	1.131	0.000	-0.067	0.134	0.132	-0.512	8.457
	South	7,924.4	-1.407	-0.391	-0.062	0.004	0.068	0.332	1.157	0.000	0.094	0.130	0.129	-0.558	8.993
	West	7,780.1	-1.344	-0.364	-0.058	0.003	0.063	0.318	1.050	0.000	0.077	0.122	0.121	-0.474	8.457
	Unk.	235.0	-1.403	-0.359	-0.054	0.004	0.059	0.304	1.032	0.000	-0.079	0.118	0.113	-0.726	10.774
5	Northeast	61.0	-1.116	-0.315	-0.035	0.002	0.040	0.260	0.751	0.000	-0.059	0.094	0.075	-1.067	14.586
	Midwest	1,509.1	-1.280	-0.344	-0.047	0.003	0.053	0.293	1.019	0.000	-0.141	0.111	0.100	-0.655	10.653
	South	305.1	-1.290	-0.370	-0.057	0.003	0.063	0.324	0.973	0.000	-0.129	0.123	0.120	-0.454	8.253
	West	4,657.7	-1.096	-0.318	-0.055	0.004	0.060	0.273	0.850	0.000	0.069	0.109	0.115	-0.493	7.486
	Unk.	190.1	-1.161	-0.379	-0.059	0.006	0.068	0.293	0.973	0.000	-0.038	0.122	0.127	-0.746	8.024
6	Northeast	104.9	-0.976	-0.309	-0.036	0.003	0.043	0.239	0.712	0.000	0.031	0.092	0.079	-1.079	12.664
	Midwest	2.1													
	South	24.9	-1.335	-0.336	-0.037	0.005	0.046	0.252	0.654	0.000	-0.313	0.098	0.083	-1.192	12.743
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-0.906	-0.261	-0.037	0.002	0.041	0.216	0.624	0.000	-0.079	0.083	0.078	-0.795	10.828
	Midwest	0.0													
	South	103.1	-1.164	-0.298	-0.034	0.004	0.041	0.214	0.701	0.000	-0.079	0.087	0.075	-1.424	14.659
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.745	-0.208	-0.028	0.002	0.032	0.163	0.475	0.000	-0.094	0.065	0.061	-1.143	12.736
	Midwest	0.0													
	South	40.9	-0.858	-0.223	-0.030	0.003	0.035	0.165	0.442	0.000	0.017	0.068	0.064	-1.427	14.387
	West	0.0													
	Unk.	0.0													

Table 69. L&R surface (space curve, 200-foot filter) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-1.261	-0.402	-0.066	0.005	0.073	0.344	1.034	0.000	-0.017	0.136	0.140	-0.498	8.958
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-1.593	-0.471	-0.075	0.005	0.083	0.397	1.287	0.000	-0.136	0.157	0.159	-0.525	8.001
	Concrete	724.6	-1.448	-0.373	-0.048	0.004	0.054	0.310	1.097	0.000	-0.048	0.116	0.102	-0.738	11.932
	Unk.	573.2	-1.527	-0.404	-0.056	0.004	0.062	0.340	1.250	0.000	0.064	0.130	0.118	-0.701	10.613
4	Timber	16,606.0	-1.402	-0.397	-0.067	0.004	0.073	0.342	1.135	0.000	-0.145	0.134	0.139	-0.482	8.042
	Concrete	3,342.8	-1.285	-0.316	-0.041	0.003	0.046	0.268	1.018	0.000	0.074	0.099	0.087	-0.761	13.459
	Unk.	2,536.6	-1.360	-0.351	-0.051	0.004	0.057	0.295	1.003	0.000	-0.097	0.114	0.108	-0.687	10.394
5	Timber	5,052.1	-1.150	-0.339	-0.059	0.004	0.065	0.289	0.939	0.000	0.069	0.116	0.125	-0.490	7.405
	Concrete	1,000.0	-1.286	-0.254	-0.034	0.002	0.037	0.225	0.888	0.000	-0.046	0.083	0.071	-0.934	18.648
	Unk.	670.8	-1.094	-0.315	-0.047	0.003	0.053	0.260	0.833	0.000	-0.050	0.103	0.100	-0.681	9.112
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.131	-0.316	-0.037	0.004	0.043	0.242	0.697	0.000	0.031	0.093	0.080	-1.104	12.707
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-1.089	-0.282	-0.035	0.003	0.041	0.215	0.728	0.000	0.035	0.085	0.076	-1.158	13.297
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.813	-0.211	-0.029	0.002	0.033	0.163	0.469	0.000	-0.072	0.066	0.062	-1.227	13.264

Table 70. L&R surface (space curve, 200-foot filter) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-1.261	-0.394	-0.063	0.006	0.071	0.325	0.971	0.000	0.043	0.132	0.135	-0.656	9.215
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-1.620	-0.480	-0.074	0.006	0.083	0.402	1.285	0.000	0.064	0.158	0.157	-0.560	8.116
	Prim. Frgt.	2,090.9	-1.490	-0.415	-0.064	0.004	0.070	0.357	1.242	0.000	0.065	0.138	0.135	-0.519	8.971
	Prim. Pass.	351.9	-1.479	-0.421	-0.058	0.004	0.065	0.348	1.265	0.000	0.073	0.133	0.122	-0.689	10.751
4	Frgt. Only	10,050.2	-1.444	-0.410	-0.065	0.004	0.071	0.351	1.143	0.000	0.063	0.137	0.136	-0.502	8.168
	Prim. Frgt.	11,799.6	-1.325	-0.355	-0.057	0.003	0.062	0.307	1.080	0.000	0.145	0.119	0.120	-0.536	9.233
	Prim. Pass.	635.6	-1.383	-0.370	-0.053	0.004	0.059	0.306	1.027	0.000	0.072	0.118	0.112	-0.684	10.373
5	Frgt. Only	2,314.9	-1.250	-0.321	-0.046	0.003	0.051	0.276	0.954	0.000	-0.066	0.105	0.097	-0.628	10.293
	Prim. Frgt.	4,171.3	-1.120	-0.333	-0.058	0.004	0.064	0.284	0.911	0.000	0.065	0.114	0.122	-0.497	7.427
	Prim. Pass.	236.7	-1.014	-0.285	-0.042	0.003	0.047	0.239	0.874	0.000	-0.087	0.093	0.089	-0.662	9.903
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.130	-0.318	-0.037	0.004	0.043	0.244	0.697	0.000	0.031	0.094	0.080	-1.095	12.650
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.089	-0.281	-0.035	0.003	0.041	0.215	0.676	0.000	0.035	0.085	0.076	-1.167	13.174
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.813	-0.211	-0.029	0.002	0.033	0.163	0.469	0.000	-0.072	0.066	0.062	-1.227	13.264

Left & Right Surface (31-foot MCO)

Table 71. L&R surface (31-foot MCO) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.9													
2	68.8	-1.493	-0.381	-0.058	0.001	0.061	0.361	1.285	0.000	0.000	0.132	0.119	-0.363	13.069
3	5,826.3	-1.770	-0.487	-0.077	0.002	0.081	0.450	1.432	0.000	0.000	0.165	0.158	-0.349	8.926
4	22,633.5	-1.570	-0.418	-0.070	0.001	0.072	0.389	1.269	-0.001	0.000	0.144	0.142	-0.319	8.835
5	6,751.6	-1.357	-0.355	-0.061	0.002	0.064	0.332	1.088	0.000	0.000	0.125	0.125	-0.307	8.368
6	136.1	-1.306	-0.348	-0.042	0.002	0.045	0.314	0.935	0.000	0.000	0.109	0.088	-0.628	13.632
7	186.6	-1.299	-0.314	-0.040	0.001	0.042	0.284	1.040	0.000	0.000	0.099	0.082	-0.651	15.304
8	158.1	-0.906	-0.237	-0.034	0.001	0.036	0.216	0.715	0.000	0.000	0.077	0.069	-0.658	14.122

Table 72. L&R surface (31-foot MCO) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.5													
	Curved	1.4													
2	Tang.	32.8	-1.540	-0.430	-0.063	0.001	0.065	0.407	1.317	0.000	0.000	0.146	0.129	-0.360	12.575
	Curved	36.0	-1.343	-0.334	-0.054	0.001	0.057	0.317	1.165	0.000	0.000	0.118	0.111	-0.352	12.388
3	Tang.	3,522.2	-1.826	-0.523	-0.082	0.002	0.086	0.480	1.462	0.000	0.000	0.177	0.168	-0.355	8.537
	Curved	2,304.1	-1.621	-0.423	-0.071	0.002	0.073	0.393	1.356	0.000	0.000	0.146	0.144	-0.320	9.068
4	Tang.	17,157.6	-1.596	-0.435	-0.073	0.001	0.075	0.403	1.291	-0.001	0.000	0.150	0.147	-0.319	8.631
	Curved	5,475.9	-1.435	-0.357	-0.062	0.001	0.063	0.334	1.168	-0.001	0.000	0.126	0.126	-0.304	8.948
5	Tang.	5,586.5	-1.374	-0.363	-0.063	0.002	0.065	0.340	1.097	0.000	0.000	0.127	0.128	-0.309	8.340
	Curved	1,165.1	-1.240	-0.311	-0.056	0.002	0.059	0.291	1.005	0.000	0.000	0.111	0.115	-0.283	7.933
6	Tang.	82.2	-1.326	-0.378	-0.044	0.002	0.048	0.337	0.940	0.000	0.000	0.116	0.092	-0.637	12.799
	Curved	54.0	-1.241	-0.295	-0.039	0.001	0.042	0.273	0.884	0.000	0.000	0.096	0.081	-0.575	14.526
7	Tang.	120.4	-1.317	-0.326	-0.041	0.001	0.044	0.295	1.077	0.000	0.000	0.102	0.085	-0.636	15.193
	Curved	66.2	-1.104	-0.291	-0.038	0.001	0.040	0.262	0.889	0.000	0.000	0.093	0.078	-0.679	15.105
8	Tang.	132.8	-0.921	-0.241	-0.034	0.001	0.036	0.220	0.699	0.000	0.000	0.078	0.069	-0.667	14.037
	Curved	25.3	-0.842	-0.209	-0.033	0.001	0.035	0.197	0.800	0.000	0.000	0.072	0.068	-0.595	14.346

Table 73. L&R surface (31-foot MCO) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.1													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.8													
	Midwest	2.6													
	South	20.2	-1.426	-0.446	-0.078	0.002	0.082	0.414	1.317	0.000	0.000	0.158	0.161	-0.379	10.441
	West	42.4	-1.294	-0.313	-0.051	0.001	0.052	0.300	1.057	0.000	0.000	0.109	0.103	-0.235	10.486
	Unk.	0.9													
3	Northeast	670.3	-1.585	-0.431	-0.071	0.002	0.074	0.397	1.342	0.000	0.000	0.147	0.145	-0.376	9.604
	Midwest	1,324.5	-1.748	-0.529	-0.081	0.002	0.085	0.485	1.459	0.000	0.000	0.179	0.165	-0.327	8.044
	South	1,927.0	-1.882	-0.511	-0.083	0.002	0.088	0.468	1.462	0.000	0.000	0.174	0.171	-0.378	8.744
	West	1,880.3	-1.726	-0.444	-0.072	0.001	0.074	0.415	1.408	-0.001	0.000	0.153	0.146	-0.312	9.349
	Unk.	24.1	-1.499	-0.447	-0.065	0.002	0.068	0.419	1.068	0.000	0.000	0.147	0.133	-0.396	9.837
4	Northeast	1,023.2	-1.553	-0.375	-0.067	0.002	0.070	0.350	1.306	0.000	0.000	0.133	0.136	-0.357	9.979
	Midwest	5,567.3	-1.634	-0.452	-0.074	0.001	0.075	0.421	1.312	-0.001	0.000	0.155	0.150	-0.306	8.470
	South	7,958.5	-1.570	-0.412	-0.071	0.002	0.074	0.382	1.274	0.000	0.000	0.143	0.145	-0.348	9.062
	West	7,848.9	-1.510	-0.403	-0.067	0.001	0.068	0.376	1.209	-0.001	0.000	0.139	0.135	-0.287	8.528
	Unk.	235.5	-1.518	-0.391	-0.061	0.002	0.063	0.365	1.240	0.000	0.000	0.134	0.124	-0.444	11.253
5	Northeast	61.1	-1.215	-0.339	-0.037	0.001	0.039	0.315	1.198	0.000	0.000	0.105	0.077	-0.702	18.711
	Midwest	1,516.8	-1.490	-0.374	-0.053	0.001	0.056	0.347	1.152	0.000	0.000	0.124	0.109	-0.443	11.229
	South	306.2	-1.490	-0.367	-0.064	0.001	0.067	0.346	1.126	0.000	0.000	0.130	0.131	-0.318	8.804
	West	4,677.4	-1.251	-0.346	-0.064	0.002	0.067	0.325	1.036	0.000	0.000	0.124	0.131	-0.253	7.320
	Unk.	190.1	-1.389	-0.415	-0.072	0.003	0.077	0.374	1.110	0.000	0.000	0.143	0.149	-0.380	7.731
6	Northeast	104.9	-1.248	-0.337	-0.041	0.001	0.044	0.306	0.909	0.000	0.000	0.105	0.085	-0.655	14.541
	Midwest	2.1													
	South	24.9	-1.474	-0.363	-0.043	0.002	0.047	0.322	0.996	0.000	0.000	0.113	0.090	-0.698	13.606
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.085	-0.276	-0.039	0.001	0.041	0.255	0.973	0.000	0.000	0.090	0.080	-0.563	14.041
	Midwest	0.0													
	South	103.1	-1.337	-0.341	-0.040	0.002	0.043	0.303	1.071	0.000	0.000	0.105	0.084	-0.696	15.375
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.857	-0.233	-0.033	0.001	0.035	0.212	0.701	0.000	0.000	0.076	0.068	-0.642	13.814
	Midwest	0.0													
	South	40.9	-0.945	-0.248	-0.035	0.001	0.037	0.227	0.764	0.000	0.000	0.081	0.072	-0.697	14.701
	West	0.0													
	Unk.	0.0													

Table 74. L&R surface (31-foot MCO) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.1													
	Unk.	0.0													
2	Timber	32.2	-1.413	-0.450	-0.076	0.002	0.079	0.418	1.317	0.000	0.000	0.155	0.155	-0.291	9.774
	Concrete	34.7	-1.538	-0.284	-0.046	0.001	0.047	0.274	1.024	0.000	0.000	0.102	0.093	-0.573	18.465
	Unk.	1.9													
3	Timber	4,422.3	-1.790	-0.506	-0.086	0.002	0.089	0.467	1.442	0.000	0.000	0.174	0.175	-0.325	8.166
	Concrete	774.6	-1.604	-0.386	-0.049	0.001	0.052	0.356	1.356	0.000	0.000	0.123	0.101	-0.486	13.951
	Unk.	629.5	-1.736	-0.434	-0.062	0.002	0.065	0.402	1.354	0.000	0.000	0.145	0.127	-0.449	11.079
4	Timber	16,706.0	-1.582	-0.433	-0.079	0.001	0.081	0.404	1.290	-0.001	0.000	0.153	0.159	-0.285	7.942
	Concrete	3,372.8	-1.484	-0.338	-0.044	0.001	0.046	0.312	1.168	0.000	0.000	0.109	0.090	-0.555	15.425
	Unk.	2,554.7	-1.572	-0.385	-0.059	0.002	0.062	0.355	1.217	0.000	0.000	0.130	0.121	-0.422	10.645
5	Timber	5,070.2	-1.325	-0.366	-0.070	0.002	0.072	0.342	1.089	0.000	0.000	0.132	0.142	-0.263	7.207
	Concrete	1,009.6	-1.487	-0.265	-0.036	0.001	0.037	0.252	1.093	0.000	0.000	0.089	0.073	-0.761	23.370
	Unk.	671.8	-1.282	-0.344	-0.054	0.002	0.057	0.317	1.056	0.000	0.000	0.118	0.112	-0.399	9.642
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.311	-0.342	-0.041	0.001	0.045	0.310	0.934	0.000	0.000	0.107	0.086	-0.666	14.356
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-1.300	-0.314	-0.040	0.001	0.042	0.284	1.040	0.000	0.000	0.099	0.082	-0.652	15.339
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-0.906	-0.237	-0.034	0.001	0.036	0.216	0.715	0.000	0.000	0.077	0.069	-0.658	14.122

Table 75. L&R surface (31-foot MCO) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.5													
	Prim. Pass.	0.4													
2	Frgt. Only	4.4													
	Prim. Frgt.	62.5	-1.382	-0.367	-0.058	0.001	0.061	0.346	1.284	0.000	0.000	0.128	0.119	-0.312	12.244
	Prim. Pass.	2.0													
3	Frgt. Only	3,225.2	-1.853	-0.526	-0.085	0.002	0.088	0.482	1.460	-0.001	0.000	0.179	0.173	-0.353	8.398
	Prim. Frgt.	2,238.1	-1.613	-0.430	-0.070	0.002	0.073	0.402	1.357	0.000	0.000	0.148	0.144	-0.306	9.037
	Prim. Pass.	363.1	-1.593	-0.429	-0.064	0.002	0.067	0.393	1.419	0.000	0.000	0.142	0.131	-0.439	10.590
4	Frgt. Only	10,104.3	-1.630	-0.453	-0.075	0.001	0.077	0.421	1.291	-0.001	0.000	0.156	0.152	-0.305	8.262
	Prim. Frgt.	11,890.5	-1.497	-0.383	-0.067	0.001	0.069	0.358	1.240	0.000	0.000	0.135	0.135	-0.322	9.076
	Prim. Pass.	638.7	-1.606	-0.395	-0.059	0.002	0.062	0.360	1.394	0.000	0.000	0.131	0.120	-0.439	11.642
5	Frgt. Only	2,325.6	-1.460	-0.352	-0.053	0.001	0.055	0.331	1.128	0.000	0.000	0.120	0.108	-0.377	10.672
	Prim. Frgt.	4,186.7	-1.281	-0.359	-0.068	0.002	0.070	0.335	1.050	0.000	0.000	0.129	0.138	-0.269	7.223
	Prim. Pass.	239.3	-1.172	-0.288	-0.045	0.001	0.047	0.268	1.018	0.000	0.000	0.098	0.092	-0.470	12.049
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.310	-0.344	-0.041	0.001	0.045	0.310	0.934	0.000	0.000	0.107	0.086	-0.668	14.252
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.300	-0.313	-0.040	0.001	0.042	0.283	1.040	0.000	0.000	0.099	0.082	-0.657	15.323
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.906	-0.237	-0.034	0.001	0.036	0.216	0.715	0.000	0.000	0.077	0.069	-0.658	14.122

Left & Right Surface (62-foot MCO)

Table 76. L&R surface (62-foot MCO) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.9													
2	68.8	-1.722	-0.485	-0.076	0.002	0.079	0.450	1.514	0.000	0.000	0.164	0.155	-0.385	10.215
3	5,826.3	-1.986	-0.593	-0.093	0.003	0.099	0.541	1.808	0.000	0.000	0.200	0.193	-0.318	8.344
4	22,633.5	-1.750	-0.506	-0.082	0.002	0.086	0.468	1.559	0.000	0.000	0.173	0.168	-0.291	8.416
5	6,751.6	-1.478	-0.437	-0.073	0.002	0.077	0.404	1.294	0.000	0.000	0.151	0.150	-0.301	8.028
6	136.1	-1.278	-0.413	-0.049	0.002	0.054	0.355	1.153	0.000	0.000	0.125	0.103	-0.624	11.456
7	186.6	-1.322	-0.350	-0.046	0.002	0.050	0.305	1.111	0.000	0.000	0.110	0.096	-0.677	12.701
8	158.1	-0.933	-0.259	-0.038	0.002	0.041	0.228	0.705	0.000	0.000	0.084	0.079	-0.699	11.688

Table 77. L&R surface (62-foot MCO) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.5													
	Curved	1.4													
2	Tang.	32.8	-1.743	-0.550	-0.079	0.002	0.084	0.505	1.571	0.000	0.000	0.180	0.163	-0.419	10.539
	Curved	36.0	-1.367	-0.425	-0.073	0.002	0.076	0.400	1.334	0.000	0.000	0.149	0.150	-0.317	8.533
3	Tang.	3,522.2	-2.037	-0.626	-0.099	0.004	0.105	0.569	1.845	0.000	0.000	0.212	0.204	-0.315	7.975
	Curved	2,304.1	-1.897	-0.533	-0.086	0.002	0.091	0.489	1.731	0.000	0.000	0.182	0.177	-0.317	8.753
4	Tang.	17,157.6	-1.781	-0.523	-0.085	0.003	0.090	0.482	1.579	0.000	0.000	0.179	0.175	-0.291	8.230
	Curved	5,475.9	-1.631	-0.445	-0.074	0.002	0.077	0.414	1.459	0.000	0.000	0.154	0.151	-0.279	8.699
5	Tang.	5,586.5	-1.491	-0.446	-0.074	0.002	0.078	0.412	1.301	0.000	0.000	0.154	0.152	-0.300	7.982
	Curved	1,165.1	-1.391	-0.388	-0.068	0.002	0.071	0.359	1.243	0.000	0.000	0.137	0.139	-0.299	7.901
6	Tang.	82.2	-1.334	-0.448	-0.052	0.002	0.057	0.379	1.180	0.000	0.000	0.134	0.109	-0.628	10.796
	Curved	54.0	-1.177	-0.345	-0.046	0.002	0.049	0.310	0.871	0.000	0.000	0.109	0.095	-0.579	11.961
7	Tang.	120.4	-1.325	-0.363	-0.048	0.002	0.052	0.319	1.176	0.000	0.000	0.115	0.099	-0.641	12.490
	Curved	66.2	-1.303	-0.320	-0.043	0.002	0.046	0.276	0.791	0.000	0.000	0.100	0.089	-0.762	12.604
8	Tang.	132.8	-0.954	-0.263	-0.038	0.002	0.041	0.230	0.708	0.000	0.000	0.085	0.079	-0.704	11.434
	Curved	25.3	-0.895	-0.238	-0.038	0.001	0.040	0.218	0.694	0.000	0.000	0.082	0.078	-0.670	13.174

Table 78. L&R surface (62-foot MCO) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.1													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.8													
	Midwest	2.6													
	South	20.2	-1.759	-0.572	-0.098	0.003	0.104	0.513	1.358	0.000	0.000	0.194	0.202	-0.403	8.202
	West	42.4	-1.314	-0.393	-0.068	0.002	0.070	0.369	1.086	0.000	0.000	0.138	0.137	-0.289	8.655
	Unk.	0.9													
3	Northeast	670.3	-1.917	-0.540	-0.083	0.002	0.088	0.492	1.879	0.000	0.000	0.180	0.171	-0.372	10.411
	Midwest	1,324.5	-1.950	-0.625	-0.096	0.003	0.103	0.570	1.837	0.000	0.000	0.211	0.198	-0.287	7.738
	South	1,927.0	-2.064	-0.621	-0.101	0.004	0.107	0.563	1.800	0.000	0.000	0.211	0.208	-0.338	8.085
	West	1,880.3	-1.896	-0.551	-0.089	0.003	0.094	0.507	1.764	0.000	0.000	0.188	0.183	-0.294	8.305
	Unk.	24.1	-1.696	-0.600	-0.083	0.003	0.089	0.554	1.334	0.000	0.000	0.194	0.171	-0.387	9.431
4	Northeast	1,023.2	-1.671	-0.452	-0.076	0.002	0.079	0.418	1.397	0.000	0.000	0.155	0.155	-0.336	9.575
	Midwest	5,567.3	-1.768	-0.535	-0.086	0.003	0.091	0.494	1.594	0.000	0.000	0.183	0.178	-0.290	8.061
	South	7,958.5	-1.785	-0.511	-0.084	0.003	0.089	0.469	1.607	0.000	0.000	0.175	0.173	-0.310	8.632
	West	7,848.9	-1.695	-0.485	-0.078	0.002	0.082	0.452	1.484	0.000	0.000	0.167	0.161	-0.259	8.164
	Unk.	235.5	-1.947	-0.481	-0.075	0.002	0.078	0.437	1.488	0.000	0.000	0.162	0.154	-0.401	9.816
5	Northeast	61.1	-1.286	-0.394	-0.045	0.002	0.048	0.359	1.022	0.000	0.000	0.120	0.093	-0.633	13.731
	Midwest	1,516.8	-1.593	-0.457	-0.063	0.002	0.067	0.421	1.398	0.000	0.000	0.150	0.130	-0.362	10.348
	South	306.2	-1.542	-0.482	-0.078	0.002	0.081	0.449	1.317	0.000	0.000	0.164	0.159	-0.274	7.924
	West	4,677.4	-1.409	-0.426	-0.076	0.002	0.080	0.395	1.217	0.000	0.000	0.150	0.156	-0.275	7.233
	Unk.	190.1	-1.440	-0.504	-0.082	0.004	0.088	0.437	1.453	0.000	0.000	0.167	0.170	-0.399	7.734
6	Northeast	104.9	-1.162	-0.392	-0.047	0.002	0.052	0.340	0.960	0.000	0.000	0.119	0.099	-0.673	11.854
	Midwest	2.1													
	South	24.9	-1.482	-0.448	-0.051	0.002	0.057	0.381	0.877	0.000	0.000	0.133	0.108	-0.650	10.980
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.108	-0.326	-0.048	0.001	0.050	0.299	0.870	0.000	0.000	0.106	0.098	-0.483	10.262
	Midwest	0.0													
	South	103.1	-1.331	-0.365	-0.044	0.002	0.049	0.308	1.000	0.000	0.000	0.112	0.093	-0.818	13.539
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-0.886	-0.255	-0.038	0.001	0.040	0.226	0.702	0.000	0.000	0.083	0.078	-0.654	11.136
	Midwest	0.0													
	South	40.9	-1.032	-0.273	-0.040	0.002	0.043	0.235	0.708	0.000	0.000	0.088	0.082	-0.805	12.845
	West	0.0													
	Unk.	0.0													

Table 79. L&R surface (62-foot MCO) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
	Timber	1.8													
1	Concrete	0.1													
	Unk.	0.0													
	Timber	32.2	-1.742	-0.566	-0.094	0.002	0.099	0.517	1.344	0.000	0.000	0.191	0.193	-0.343	7.920
2	Concrete	34.7	-1.694	-0.368	-0.063	0.001	0.065	0.347	1.565	0.000	0.000	0.132	0.128	-0.450	14.012
	Unk.	1.9													
	Timber	4,422.3	-2.025	-0.616	-0.103	0.004	0.109	0.562	1.841	0.000	0.000	0.211	0.213	-0.298	7.724
3	Concrete	774.6	-1.716	-0.472	-0.061	0.002	0.066	0.428	1.518	0.000	0.000	0.151	0.127	-0.437	11.840
	Unk.	629.5	-1.895	-0.527	-0.076	0.002	0.081	0.481	1.739	0.000	0.000	0.175	0.157	-0.402	9.865
	Timber	16,706.0	-1.774	-0.526	-0.092	0.003	0.096	0.486	1.592	0.000	0.000	0.183	0.189	-0.264	7.672
4	Concrete	3,372.8	-1.600	-0.408	-0.053	0.002	0.056	0.377	1.417	0.000	0.000	0.131	0.110	-0.457	13.229
	Unk.	2,554.7	-1.743	-0.461	-0.070	0.002	0.074	0.423	1.426	0.000	0.000	0.155	0.143	-0.385	9.767
	Timber	5,070.2	-1.460	-0.452	-0.083	0.003	0.086	0.417	1.301	0.000	0.000	0.159	0.169	-0.273	7.106
5	Concrete	1,009.6	-1.593	-0.335	-0.043	0.001	0.045	0.316	1.268	0.000	0.000	0.110	0.089	-0.564	18.666
	Unk.	671.8	-1.345	-0.415	-0.064	0.002	0.068	0.378	1.263	0.000	0.000	0.140	0.132	-0.357	8.786
	Timber	4.6													
6	Concrete	1.5													
	Unk.	130.0	-1.279	-0.405	-0.048	0.002	0.052	0.348	0.948	0.000	0.000	0.122	0.100	-0.668	11.697
	Timber	0.3													
7	Concrete	0.0													
	Unk.	186.3	-1.322	-0.349	-0.046	0.002	0.050	0.305	1.111	0.000	0.000	0.110	0.096	-0.677	12.722
	Timber	0.0													
8	Concrete	0.0													
	Unk.	158.1	-0.933	-0.259	-0.038	0.002	0.041	0.228	0.705	0.000	0.000	0.084	0.079	-0.699	11.688

Table 80. L&R surface (62-foot MCO) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
	Frgt. Only	0.0													
1	Prim. Frgt.	1.5													
	Prim. Pass.	0.4													
	Frgt. Only	4.4													
2	Prim. Frgt.	62.5	-1.699	-0.459	-0.076	0.002	0.079	0.424	1.208	0.000	0.000	0.158	0.155	-0.382	9.198
	Prim. Pass.	2.0													
	Frgt. Only	3,225.2	-2.029	-0.625	-0.101	0.004	0.107	0.568	1.827	0.000	0.000	0.213	0.208	-0.315	7.749
3	Prim. Frgt.	2,238.1	-1.917	-0.541	-0.086	0.002	0.091	0.499	1.774	0.000	0.000	0.184	0.177	-0.304	8.938
	Prim. Pass.	363.1	-1.921	-0.562	-0.079	0.003	0.085	0.506	1.755	0.000	0.000	0.181	0.164	-0.390	10.383
	Frgt. Only	10,104.3	-1.812	-0.541	-0.089	0.003	0.093	0.499	1.594	0.000	0.000	0.186	0.182	-0.277	7.791
4	Prim. Frgt.	11,890.5	-1.684	-0.472	-0.078	0.002	0.082	0.436	1.523	0.000	0.000	0.162	0.160	-0.300	8.883
	Prim. Pass.	638.7	-1.644	-0.490	-0.073	0.002	0.077	0.443	1.364	0.000	0.000	0.161	0.150	-0.385	9.486
	Frgt. Only	2,325.6	-1.552	-0.428	-0.063	0.002	0.066	0.398	1.320	0.000	0.000	0.143	0.128	-0.348	9.740
5	Prim. Frgt.	4,186.7	-1.437	-0.445	-0.081	0.003	0.084	0.410	1.283	0.000	0.000	0.157	0.165	-0.278	7.221
	Prim. Pass.	239.3	-1.251	-0.374	-0.057	0.002	0.060	0.345	1.210	0.000	0.000	0.125	0.117	-0.361	9.080
	Frgt. Only	0.4													
6	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.279	-0.410	-0.048	0.002	0.053	0.352	0.948	0.000	0.000	0.123	0.101	-0.667	11.682
	Frgt. Only	0.2													
7	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.300	-0.348	-0.046	0.002	0.049	0.304	0.964	0.000	0.000	0.109	0.095	-0.682	12.279
	Frgt. Only	0.0													
8	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-0.933	-0.259	-0.038	0.002	0.041	0.228	0.705	0.000	0.000	0.084	0.079	-0.699	11.688

Left & Right Surface (124-foot MCO)

Table 81. L&R surface (124-foot MCO) statistics by FRA track class

Class	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
		0.001	1	25	50	75	99	99.999						
1	1.8													
2	28.1	-2.319	-0.727	-0.129	0.005	0.137	0.657	2.317	0.001	0.000	0.255	0.266	-0.071	8.213
3	5,521.8	-2.945	-0.894	-0.148	0.005	0.155	0.835	2.836	0.000	0.000	0.308	0.303	-0.159	7.722
4	22,485.4	-2.349	-0.734	-0.123	0.003	0.128	0.696	2.391	0.000	0.000	0.254	0.251	-0.122	7.887
5	6,722.9	-1.946	-0.624	-0.108	0.003	0.113	0.581	1.983	0.000	0.000	0.217	0.221	-0.176	7.516
6	136.1	-1.628	-0.589	-0.086	0.003	0.090	0.544	1.597	0.000	0.000	0.192	0.176	-0.206	8.209
7	186.6	-1.554	-0.531	-0.081	0.002	0.086	0.482	1.417	0.000	0.000	0.175	0.168	-0.277	7.867
8	158.1	-1.270	-0.390	-0.062	0.002	0.065	0.351	1.035	0.000	0.000	0.130	0.127	-0.415	8.594

Table 82. L&R surface (124-foot MCO) statistics by track curvature

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Tang.	0.4													
	Curved	1.4													
2	Tang.	18.7	-2.334	-0.738	-0.128	0.004	0.136	0.679	2.322	0.001	0.000	0.259	0.264	0.010	9.054
	Curved	9.3													
3	Tang.	3,381.9	-2.887	-0.906	-0.149	0.005	0.156	0.851	2.757	0.000	0.000	0.313	0.305	-0.136	7.579
	Curved	2,139.9	-3.050	-0.875	-0.146	0.004	0.153	0.808	2.927	0.000	0.000	0.302	0.299	-0.200	7.957
4	Tang.	17,049.2	-2.361	-0.748	-0.125	0.003	0.130	0.711	2.420	0.000	0.000	0.259	0.255	-0.116	7.806
	Curved	5,436.2	-2.315	-0.685	-0.117	0.003	0.122	0.646	2.298	0.000	0.000	0.239	0.239	-0.143	8.046
5	Tang.	5,562.2	-1.959	-0.635	-0.109	0.003	0.114	0.592	2.020	0.000	0.000	0.220	0.223	-0.169	7.529
	Curved	1,160.6	-1.878	-0.570	-0.103	0.003	0.109	0.525	1.742	0.001	0.000	0.201	0.212	-0.217	7.194
6	Tang.	82.2	-1.695	-0.624	-0.089	0.003	0.094	0.571	1.623	0.000	0.000	0.202	0.183	-0.211	8.169
	Curved	54.0	-1.314	-0.531	-0.081	0.002	0.085	0.497	1.245	0.001	0.000	0.175	0.166	-0.187	7.743
7	Tang.	120.4	-1.471	-0.553	-0.085	0.002	0.089	0.503	1.455	0.000	0.000	0.183	0.174	-0.248	7.563
	Curved	66.2	-1.613	-0.488	-0.076	0.002	0.080	0.436	1.181	0.000	0.000	0.161	0.156	-0.348	8.364
8	Tang.	132.8	-1.281	-0.395	-0.062	0.002	0.065	0.354	1.043	0.000	0.000	0.130	0.127	-0.385	8.418
	Curved	25.3	-1.247	-0.360	-0.060	0.003	0.066	0.337	0.798	0.001	0.000	0.126	0.126	-0.591	9.634

Table 83. L&R surface (124-foot MCO) statistics by geographical region

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Northeast	0.0													
	Midwest	0.0													
	South	0.0													
	West	1.8													
	Unk.	0.0													
2	Northeast	2.3													
	Midwest	1.3													
	South	20.1	-2.333	-0.726	-0.131	0.004	0.138	0.650	2.322	0.000	0.000	0.257	0.269	-0.101	8.801
	West	3.6													
	Unk.	0.7													
3	Northeast	637.5	-3.000	-0.795	-0.122	0.004	0.130	0.728	2.720	0.000	0.000	0.267	0.252	-0.313	10.227
	Midwest	1,274.7	-2.521	-0.900	-0.143	0.004	0.150	0.846	3.084	0.000	0.000	0.309	0.293	-0.057	7.970
	South	1,859.4	-3.075	-0.958	-0.163	0.006	0.171	0.893	2.751	0.000	0.000	0.332	0.333	-0.177	7.180
	West	1,727.3	-2.895	-0.843	-0.147	0.004	0.154	0.789	2.701	0.000	0.000	0.295	0.301	-0.172	7.292
	Unk.	23.0	-2.572	-0.868	-0.132	0.006	0.141	0.781	2.014	-0.001	0.000	0.292	0.273	-0.279	7.717
4	Northeast	1,020.6	-2.321	-0.623	-0.106	0.002	0.110	0.590	2.148	0.000	0.000	0.216	0.215	-0.214	9.307
	Midwest	5,525.3	-2.383	-0.756	-0.129	0.003	0.133	0.724	2.507	0.000	0.000	0.264	0.262	-0.081	7.732
	South	7,924.4	-2.397	-0.768	-0.126	0.004	0.131	0.722	2.477	0.000	0.000	0.263	0.257	-0.140	7.999
	West	7,780.1	-2.254	-0.695	-0.121	0.003	0.124	0.662	2.111	0.000	0.000	0.243	0.245	-0.125	7.480
	Unk.	235.0	-2.394	-0.672	-0.111	0.003	0.115	0.627	2.568	0.000	0.000	0.231	0.227	-0.122	8.901
5	Northeast	61.0	-1.685	-0.621	-0.083	0.002	0.086	0.566	1.943	0.000	0.000	0.197	0.169	-0.202	10.503
	Midwest	1,509.1	-1.965	-0.644	-0.103	0.002	0.106	0.617	2.365	0.000	0.000	0.221	0.209	-0.102	8.415
	South	305.1	-2.163	-0.759	-0.119	0.003	0.124	0.722	2.075	0.000	0.000	0.257	0.243	-0.138	7.707
	West	4,657.7	-1.898	-0.605	-0.109	0.003	0.114	0.558	1.845	0.000	0.000	0.212	0.223	-0.201	7.066
	Unk.	190.1	-1.963	-0.677	-0.119	0.006	0.127	0.608	1.922	0.000	0.000	0.233	0.247	-0.273	6.419
6	Northeast	104.9	-1.452	-0.574	-0.084	0.002	0.088	0.533	1.475	0.000	0.000	0.187	0.171	-0.206	8.232
	Midwest	2.1													
	South	24.9	-1.898	-0.591	-0.086	0.003	0.092	0.541	1.346	0.000	0.000	0.194	0.179	-0.317	8.229
	West	4.2													
	Unk.	0.0													
7	Northeast	83.3	-1.358	-0.523	-0.083	0.002	0.085	0.492	1.488	0.000	0.000	0.176	0.168	-0.117	7.638
	Midwest	0.0													
	South	103.1	-1.605	-0.536	-0.080	0.003	0.086	0.473	1.139	0.000	0.000	0.174	0.167	-0.420	7.950
	West	0.2													
	Unk.	0.0													
8	Northeast	117.2	-1.204	-0.383	-0.060	0.002	0.063	0.347	1.055	0.000	0.000	0.127	0.123	-0.323	8.478
	Midwest	0.0													
	South	40.9	-1.328	-0.413	-0.067	0.002	0.072	0.359	0.955	0.000	0.000	0.138	0.139	-0.619	8.691
	West	0.0													
	Unk.	0.0													

Table 84. L&R surface (124-foot MCO) statistics by tie type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Timber	1.8													
	Concrete	0.0													
	Unk.	0.0													
2	Timber	24.3	-2.328	-0.729	-0.130	0.004	0.137	0.665	2.321	0.000	0.000	0.258	0.267	-0.054	8.402
	Concrete	2.0													
	Unk.	1.8													
3	Timber	4,224.1	-2.971	-0.925	-0.158	0.005	0.166	0.862	2.883	0.000	0.000	0.321	0.324	-0.152	7.361
	Concrete	724.6	-2.843	-0.765	-0.114	0.002	0.119	0.718	2.529	0.000	0.000	0.256	0.233	-0.183	9.179
	Unk.	573.2	-2.730	-0.788	-0.125	0.002	0.129	0.741	2.673	0.000	0.000	0.269	0.254	-0.202	8.525
4	Timber	16,606.0	-2.397	-0.762	-0.134	0.004	0.139	0.722	2.428	0.000	0.000	0.267	0.272	-0.120	7.420
	Concrete	3,342.8	-2.096	-0.617	-0.094	0.002	0.096	0.592	2.211	0.000	0.000	0.208	0.190	-0.093	9.837
	Unk.	2,536.6	-2.252	-0.657	-0.107	0.003	0.111	0.625	2.253	0.000	0.000	0.226	0.219	-0.160	8.747
5	Timber	5,052.1	-1.970	-0.647	-0.117	0.004	0.122	0.598	1.980	0.000	0.000	0.226	0.239	-0.180	7.019
	Concrete	1,000.0	-1.905	-0.505	-0.079	0.001	0.080	0.496	2.129	0.000	0.000	0.173	0.159	-0.071	11.613
	Unk.	670.8	-1.708	-0.580	-0.099	0.003	0.103	0.535	1.805	0.000	0.000	0.200	0.202	-0.216	7.349
6	Timber	4.6													
	Concrete	1.5													
	Unk.	130.0	-1.633	-0.579	-0.084	0.003	0.089	0.536	1.416	0.000	0.000	0.188	0.173	-0.229	8.230
7	Timber	0.3													
	Concrete	0.0													
	Unk.	186.3	-1.554	-0.531	-0.081	0.002	0.086	0.482	1.417	0.000	0.000	0.175	0.167	-0.277	7.874
8	Timber	0.0													
	Concrete	0.0													
	Unk.	158.1	-1.270	-0.390	-0.062	0.002	0.065	0.351	1.035	0.000	0.000	0.130	0.127	-0.415	8.594

Table 85. L&R surface (124-foot MCO) statistics by traffic type

Class	Category	Usable Mileage	Percentiles							Mean	Mode	St.D.	IQR	S	K
			0.001	1	25	50	75	99	99.999						
1	Frgt. Only	0.0													
	Prim. Frgt.	1.4													
	Prim. Pass.	0.4													
2	Frgt. Only	1.3													
	Prim. Frgt.	25.1	-2.326	-0.728	-0.126	0.005	0.135	0.638	2.320	0.000	0.000	0.251	0.261	-0.189	8.399
	Prim. Pass.	1.7													
3	Frgt. Only	3,079.1	-2.862	-0.930	-0.157	0.005	0.164	0.869	2.923	0.000	0.000	0.322	0.320	-0.125	7.309
	Prim. Frgt.	2,090.9	-3.050	-0.847	-0.141	0.004	0.148	0.789	2.685	0.000	0.000	0.293	0.289	-0.216	8.087
	Prim. Pass.	351.9	-2.907	-0.817	-0.122	0.004	0.129	0.754	2.560	0.000	0.000	0.272	0.251	-0.216	9.628
4	Frgt. Only	10,050.2	-2.402	-0.782	-0.133	0.003	0.137	0.744	2.468	0.000	0.000	0.273	0.270	-0.095	7.441
	Prim. Frgt.	11,799.6	-2.306	-0.688	-0.117	0.003	0.121	0.652	2.290	0.000	0.000	0.239	0.238	-0.151	8.165
	Prim. Pass.	635.6	-2.171	-0.693	-0.111	0.002	0.116	0.649	2.138	0.000	0.000	0.235	0.227	-0.180	8.291
5	Frgt. Only	2,314.9	-1.918	-0.598	-0.097	0.002	0.100	0.569	2.142	0.000	0.000	0.204	0.197	-0.144	8.709
	Prim. Frgt.	4,171.3	-1.974	-0.641	-0.117	0.004	0.122	0.590	1.923	0.000	0.000	0.225	0.239	-0.189	6.943
	Prim. Pass.	236.7	-1.634	-0.560	-0.090	0.002	0.093	0.517	1.938	0.000	0.000	0.189	0.183	-0.175	8.167
6	Frgt. Only	0.4													
	Prim. Frgt.	4.8													
	Prim. Pass.	131.0	-1.632	-0.585	-0.085	0.003	0.089	0.541	1.415	0.000	0.000	0.190	0.174	-0.217	8.260
7	Frgt. Only	0.2													
	Prim. Frgt.	0.3													
	Prim. Pass.	186.1	-1.554	-0.530	-0.081	0.002	0.086	0.481	1.417	0.000	0.000	0.175	0.167	-0.282	7.815
8	Frgt. Only	0.0													
	Prim. Frgt.	0.0													
	Prim. Pass.	158.1	-1.270	-0.390	-0.062	0.002	0.065	0.351	1.035	0.000	0.000	0.130	0.127	-0.415	8.594

Appendix B.
Bivariate Distribution Tables

This appendix contains the bivariate distribution tables described in Section 5.2.

31-foot MCO

Table 1. 31-foot MCO (FRA Class 2 track)

CLASS 2	31 ft MCO	Inward alignment deviation exceeding:													Outward alignment deviation exceeding:														TOTAL
		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	
Upward surface deviation exceeding:	2																											
	1 3/4																											
	1 1/2																											
	1 1/4												0.03	0.03	0.08	0.08	0.04											0.11
	1						0.01	0.02	0.02	0.02	0.02	0.09	0.25	0.57	0.47	0.30	0.17	0.03	0.02	0.02	0.01							1.04
	7/8						0.01	0.02	0.02	0.06	0.08	0.20	0.60	1.40	0.89	0.38	0.19	0.03	0.02	0.02	0.01							2.30
	3/4						0.01	0.02	0.03	0.09	0.14	0.31	0.99	2.96	1.86	0.56	0.25	0.04	0.03	0.02	0.01							4.82
	5/8						0.01	0.02	0.04	0.11	0.18	0.52	1.64	5.81	3.59	0.95	0.36	0.07	0.05	0.02	0.01							9.41
	1/2						0.01	0.02	0.06	0.19	0.42	1.20	3.40	12.46	8.15	1.86	0.62	0.17	0.07	0.03	0.01							20.61
	3/8						0.01	0.04	0.10	0.28	0.67	2.17	7.17	28.13	19.45	4.17	1.03	0.24	0.10	0.04	0.01							47.58
	1/4						0.01	0.04	0.12	0.34	1.00	3.65	16.74	80.31	60.04	10.04	1.88	0.49	0.16	0.07	0.02							140.36
	1/8						0.01	0.04	0.14	0.50	1.69	6.83	40.88	313.75	269.77	29.79	4.02	0.95	0.29	0.08	0.02							583.51
	0						0.01	0.05	0.17	0.60	2.31	11.87	97.83	1373.54	1304.84	79.45	8.23	1.59	0.42	0.09	0.03							2678.38
Downward surface deviation exceeding:	0						0.02	0.10	0.28	0.51	2.20	10.28	80.20	1247.58	1354.05	97.67	12.47	2.87	0.65	0.25	0.10	0.01						2601.62
	- 1/8						0.02	0.09	0.25	0.40	1.40	5.22	29.52	264.25	315.81	43.59	6.87	2.05	0.48	0.20	0.09	0.01						580.06
	- 1/4						0.01	0.06	0.15	0.23	0.68	2.04	9.53	61.38	88.31	19.24	4.03	1.43	0.33	0.17	0.09	0.01						149.69
	- 3/8						0.01	0.01	0.09	0.16	0.36	0.95	3.81	21.11	33.95	9.01	2.03	0.86	0.23	0.15	0.08	0.01						55.06
	- 1/2							0.01	0.04	0.09	0.20	0.46	1.62	9.26	16.23	4.65	1.07	0.41	0.13	0.10	0.05	0.01						25.49
	- 5/8								0.02	0.05	0.11	0.25	0.81	4.44	8.85	2.67	0.62	0.18	0.07	0.05	0.02							13.29
	- 3/4								0.01	0.04	0.09	0.18	0.52	2.48	5.23	1.47	0.33	0.09	0.03	0.02	0.01							7.71
	- 7/8									0.01	0.02	0.09	0.24	1.41	3.18	0.87	0.23	0.05	0.01	0.01	0.01							4.59
	-1											0.03	0.05	0.81	1.90	0.45	0.15	0.03										2.71
	-1 1/4													0.17	0.44	0.09	0.03	0.03										0.60
	-1 1/2														0.05													0.05
	-1 3/4																											
	-2																											
TOTAL							0.04	0.15	0.45	1.11	4.52	22.15	178.02	2621.11	2658.89	177.12	20.70	4.46	1.08	0.33	0.13	0.01						

Table 2. 31-foot MCO (FRA Class 3 track)

CLASS 3		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													
31 ft MCO		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	TOTAL
Upward surface deviation exceeding:	2								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00												0.00
	1 3/4								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										0.01
	1 1/2								0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00								0.03
	1 1/4								0.00	0.00	0.01	0.02	0.06	0.13	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00						0.20
	1							0.00	0.00	0.01	0.02	0.08	0.28	0.69	0.46	0.15	0.04	0.01	0.00	0.00	0.00	0.00	0.00					1.14
	7/8							0.00	0.00	0.01	0.04	0.17	0.62	1.60	1.06	0.34	0.08	0.02	0.01	0.00	0.00	0.00	0.00					2.66
	3/4					0.00	0.00	0.00	0.00	0.02	0.08	0.34	1.35	3.72	2.55	0.74	0.16	0.04	0.01	0.00	0.00	0.00	0.00					6.27
	5/8				0.00	0.00	0.00	0.00	0.01	0.03	0.15	0.68	2.95	8.69	6.31	1.70	0.35	0.07	0.02	0.01	0.00	0.00	0.00					14.99
	1/2				0.00	0.00	0.00	0.01	0.02	0.06	0.29	1.35	6.47	20.77	15.68	3.91	0.74	0.14	0.03	0.01	0.00	0.00	0.00					36.44
	3/8				0.00	0.00	0.00	0.01	0.03	0.11	0.52	2.66	14.32	52.18	41.23	9.25	1.60	0.29	0.06	0.01	0.00	0.00	0.00					93.41
	1/4				0.00	0.00	0.01	0.02	0.05	0.19	0.89	5.16	33.10	144.37	120.76	23.08	3.41	0.56	0.11	0.02	0.01	0.00	0.00					265.13
	1/8				0.00	0.00	0.01	0.02	0.08	0.30	1.49	9.93	79.79	454.85	404.19	61.25	7.37	1.10	0.21	0.04	0.01	0.00	0.00					859.04
	0				0.00	0.00	0.01	0.03	0.11	0.44	2.39	17.72	176.00	1379.47	1304.50	150.67	14.94	2.01	0.36	0.07	0.02	0.01	0.00					2683.97
Downward surface deviation exceeding:	0			0.00	0.00	0.01	0.01	0.03	0.12	0.47	2.36	16.10	151.29	1249.77	1346.25	177.15	19.32	2.75	0.53	0.13	0.04	0.02	0.01	0.00				2596.03
	- 1/8			0.00	0.00	0.00	0.01	0.03	0.08	0.31	1.43	8.52	63.33	390.69	452.55	83.99	11.47	1.85	0.38	0.10	0.03	0.01	0.01	0.00				843.25
	- 1/4			0.00	0.00	0.00	0.01	0.02	0.05	0.19	0.84	4.33	25.66	123.80	154.40	38.00	6.53	1.21	0.26	0.07	0.02	0.01	0.01	0.00				278.20
	- 3/8			0.00	0.00	0.00	0.00	0.01	0.03	0.12	0.48	2.28	11.46	46.87	62.41	18.60	3.83	0.79	0.17	0.04	0.01	0.01	0.00	0.00				109.28
	- 1/2			0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.28	1.23	5.55	20.33	28.50	9.71	2.31	0.51	0.12	0.03	0.01	0.00	0.00	0.00				48.83
	- 5/8			0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.16	0.68	2.83	9.64	14.14	5.30	1.39	0.33	0.07	0.02	0.00	0.00	0.00					23.77
	- 3/4			0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.09	0.38	1.49	4.80	7.38	2.98	0.85	0.21	0.05	0.01	0.00	0.00	0.00					12.19
	- 7/8			0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.22	0.80	2.46	3.94	1.70	0.53	0.14	0.03	0.01	0.00	0.00	0.00					6.40
	-1			0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.12	0.43	1.28	2.13	0.96	0.32	0.09	0.02	0.00	0.00	0.00	0.00					3.41
	-1 1/4			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.11	0.33	0.63	0.30	0.12	0.04	0.01	0.00								0.96
	-1 1/2							0.00	0.00	0.00	0.00	0.01	0.03	0.08	0.17	0.08	0.03	0.01	0.00	0.00								0.25
	-1 3/4							0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.02	0.01	0.00	0.00	0.00								0.06
	-2								0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00								0.01
TOTAL				0.00	0.00	0.01	0.02	0.06	0.23	0.91	4.75	33.82	327.30	2629.24	2650.76	327.82	34.26	4.76	0.89	0.20	0.06	0.02	0.01	0.00				

Table 3. 31-foot MCO (FRA Class 4 track)

CLASS 4		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													TOTAL
31 ft MCO		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	
Upward surface deviation exceeding:	2												0.00	0.00	0.00	0.00												0.00
	1 3/4												0.00	0.00	0.00	0.00												0.00
	1 1/2									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										0.01
	1 1/4							0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.01	0.00	0.00	0.00	0.00								0.06
	1							0.00	0.00	0.00	0.00	0.02	0.09	0.26	0.20	0.05	0.01	0.00	0.00	0.00								0.46
	7/8							0.00	0.00	0.00	0.01	0.04	0.21	0.69	0.54	0.14	0.02	0.00	0.00	0.00								1.24
	3/4						0.00	0.00	0.00	0.01	0.02	0.10	0.51	1.78	1.42	0.34	0.06	0.01	0.00	0.00								3.20
	5/8						0.00	0.00	0.00	0.01	0.05	0.23	1.21	4.52	3.66	0.83	0.14	0.02	0.00	0.00	0.00							8.18
	1/2						0.00	0.00	0.01	0.03	0.10	0.50	2.81	11.58	9.72	2.04	0.33	0.05	0.01	0.00	0.00	0.00	0.00					21.31
	3/8					0.00	0.00	0.00	0.01	0.05	0.20	1.06	6.69	31.80	27.71	5.16	0.77	0.12	0.02	0.00	0.00	0.00	0.00					59.51
	1/4					0.00	0.00	0.00	0.02	0.08	0.38	2.22	16.95	100.02	90.92	14.07	1.80	0.27	0.05	0.01	0.00	0.00	0.00	0.00				190.95
	1/8			0.00	0.00	0.00	0.00	0.01	0.03	0.14	0.70	4.75	47.59	376.48	358.38	43.19	4.47	0.61	0.10	0.02	0.00	0.00	0.00	0.00	0.00			734.86
	0			0.00	0.00	0.00	0.00	0.01	0.05	0.22	1.23	9.80	125.00	1350.39	1325.34	120.82	10.05	1.19	0.18	0.03	0.01	0.00	0.00	0.00	0.00			2675.73
Downward surface deviation exceeding:	0			0.00	0.00	0.00	0.00	0.01	0.05	0.25	1.36	10.38	121.88	1281.11	1323.17	128.80	11.28	1.42	0.23	0.05	0.01	0.00	0.00	0.00	0.00	0.00		2604.27
	- 1/8			0.00	0.00	0.00	0.00	0.01	0.04	0.16	0.78	5.01	45.31	352.43	380.82	51.76	5.77	0.86	0.16	0.04	0.01	0.00	0.00	0.00	0.00	0.00		733.25
	- 1/4			0.00	0.00	0.00	0.00	0.01	0.03	0.10	0.43	2.28	15.89	95.97	110.56	20.37	2.92	0.52	0.11	0.03	0.01	0.00	0.00	0.00	0.00	0.00		206.53
	- 3/8			0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.24	1.11	6.45	32.46	39.96	9.20	1.58	0.31	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00		72.41
	- 1/2					0.00	0.00	0.00	0.01	0.04	0.14	0.57	2.94	13.15	17.15	4.60	0.88	0.19	0.04	0.01	0.00	0.00	0.00					30.30
	- 5/8					0.00	0.00	0.00	0.01	0.02	0.08	0.30	1.44	5.92	8.06	2.40	0.50	0.11	0.02	0.01	0.00	0.00	0.00					13.98
	- 3/4					0.00	0.00	0.00	0.00	0.01	0.04	0.16	0.72	2.81	3.98	1.28	0.28	0.07	0.01	0.00	0.00	0.00	0.00					6.79
	- 7/8					0.00	0.00	0.00	0.00	0.01	0.02	0.08	0.36	1.36	1.98	0.67	0.16	0.04	0.01	0.00	0.00	0.00	0.00					3.34
	-1					0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.18	0.65	0.97	0.34	0.08	0.02	0.00	0.00	0.00	0.00	0.00					1.62
	-1 1/4						0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.15	0.22	0.08	0.02	0.01	0.00	0.00	0.00	0.00						0.37
	-1 1/2							0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.02	0.01	0.00	0.00	0.00								0.08
	-1 3/4							0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00									0.02
	-2								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											0.00
TOTAL				0.00	0.00	0.00	0.01	0.02	0.10	0.46	2.59	20.18	246.88	2631.50	2648.50	249.61	21.33	2.62	0.42	0.08	0.02	0.01	0.00	0.00	0.00	0.00		

Table 4. 31-foot MCO (FRA Class 5 track)

CLASS 5		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													
31 ft MCO		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	TOTAL
Upward surface deviation exceeding:	2																											
	1 3/4												0.00	0.00														0.00
	1 1/2												0.00	0.00														0.00
	1 1/4										0.00	0.00	0.00	0.00	0.00	0.00	0.00											0.01
	1									0.00	0.00	0.00	0.02	0.06	0.05	0.01	0.00	0.00										0.11
	7/8								0.00	0.00	0.00	0.01	0.05	0.19	0.16	0.03	0.00	0.00										0.35
	3/4							0.00	0.00	0.00	0.01	0.03	0.16	0.60	0.54	0.11	0.02	0.00	0.00	0.00								1.14
	5/8							0.00	0.00	0.01	0.02	0.09	0.43	1.85	1.66	0.32	0.05	0.01	0.00	0.00								3.51
	1/2							0.00	0.01	0.02	0.05	0.22	1.18	5.54	5.14	0.96	0.15	0.03	0.01	0.00	0.00							10.68
	3/8							0.00	0.01	0.03	0.10	0.53	3.21	17.48	16.84	2.86	0.42	0.08	0.02	0.00	0.00	0.00						34.33
	1/4							0.00	0.01	0.05	0.23	1.31	9.63	64.50	64.04	9.11	1.19	0.20	0.03	0.01	0.00	0.00						128.54
	1/8						0.00	0.00	0.01	0.09	0.53	3.62	34.60	303.84	306.03	34.96	3.86	0.56	0.08	0.01	0.00	0.00						609.87
	0					0.00	0.00	0.00	0.03	0.16	1.25	9.97	114.36	1341.83	1346.33	117.77	11.36	1.45	0.18	0.03	0.00	0.00						2688.16
Downward surface deviation exceeding:	0					0.00	0.00	0.01	0.03	0.22	1.57	11.86	120.65	1293.38	1298.46	123.04	12.64	1.64	0.22	0.04	0.01	0.00	0.00	0.00				2591.84
	- 1/8					0.00	0.00	0.00	0.02	0.11	0.72	4.70	39.23	302.91	305.95	40.69	5.06	0.77	0.13	0.03	0.01	0.00	0.00	0.00				608.86
	- 1/4						0.00	0.00	0.01	0.05	0.30	1.66	11.40	70.35	73.57	12.60	1.94	0.35	0.07	0.02	0.01	0.00	0.00					143.92
	- 3/8							0.00	0.00	0.03	0.14	0.69	4.03	21.22	23.26	4.88	0.89	0.18	0.04	0.01	0.01	0.00	0.00					44.48
	- 1/2								0.00	0.01	0.07	0.31	1.66	7.83	9.11	2.22	0.46	0.10	0.03	0.01	0.00	0.00	0.00					16.94
	- 5/8								0.00	0.01	0.04	0.15	0.72	3.19	3.96	1.06	0.23	0.05	0.02	0.00	0.00	0.00	0.00					7.15
	- 3/4								0.00	0.00	0.02	0.07	0.31	1.36	1.79	0.50	0.12	0.03	0.01	0.00	0.00	0.00	0.00					3.15
	- 7/8								0.00	0.00	0.01	0.03	0.13	0.59	0.81	0.24	0.06	0.01	0.01	0.00	0.00	0.00						1.40
	-1								0.00	0.00	0.00	0.01	0.06	0.26	0.36	0.11	0.03	0.01	0.00	0.00	0.00	0.00						0.62
	-1 1/4										0.00	0.00	0.01	0.05	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00						0.11
	-1 1/2										0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00										0.02
	-1 3/4												0.00	0.00	0.00	0.00	0.00	0.00										0.00
	-2																											
TOTAL						0.00	0.00	0.01	0.05	0.38	2.82	21.83	235.01	2635.22	2644.78	240.81	24.00	3.09	0.41	0.07	0.02	0.01	0.00	0.00				

Table 5. 31-foot MCO (FRA Class 6 track)

CLASS 6 31 ft MCO		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													TOTAL
		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	TOTAL
Upward surface deviation exceeding:	2																											
	1 3/4																											
	1 1/2																											
	1 1/4																											
	1													0.00	0.01	0.01												0.01
	7/8												0.04	0.12	0.06	0.05												0.18
	3/4										0.02	0.04	0.24	0.58	0.38	0.14	0.01											0.95
	5/8										0.04	0.16	0.74	2.05	1.23	0.33	0.06	0.01										3.28
	1/2										0.08	0.35	1.88	6.48	4.09	0.71	0.09	0.01										10.57
	3/8									0.01	0.13	0.61	4.12	18.14	12.66	1.73	0.22	0.02										30.80
	1/4									0.03	0.26	1.22	9.53	53.74	41.82	4.83	0.51	0.07	0.01									95.55
	1/8									0.06	0.43	2.40	22.42	200.18	178.06	15.75	1.47	0.13	0.03									378.25
	0									0.09	0.58	4.22	60.70	1356.84	1348.60	57.72	3.20	0.28	0.04									2705.44
Downward surface deviation exceeding:	0									0.03	0.38	3.65	54.84	1276.59	1297.96	64.02	4.82	0.81	0.22	0.04								2574.56
	- 1/8									0.02	0.25	2.06	17.32	172.73	204.07	25.65	2.98	0.68	0.19	0.04								376.80
	- 1/4									0.01	0.12	1.11	6.76	45.69	63.40	13.12	1.90	0.46	0.14	0.03								109.10
	- 3/8									0.01	0.07	0.61	3.10	16.95	26.78	7.14	1.22	0.29	0.12	0.03								43.73
	- 1/2									0.01	0.06	0.33	1.36	6.88	12.60	3.97	0.80	0.21	0.08	0.03								19.48
	- 5/8									0.01	0.05	0.16	0.57	2.90	6.34	2.27	0.47	0.14	0.07	0.02								9.23
	- 3/4										0.03	0.08	0.28	1.12	3.17	1.40	0.30	0.11	0.05	0.02								4.29
	- 7/8										0.02	0.06	0.15	0.42	1.34	0.73	0.17	0.07	0.03	0.01								1.76
	-1										0.01	0.03	0.06	0.09	0.47	0.30	0.11	0.06	0.02	0.01								0.56
	-1 1/4											0.01	0.01	0.01	0.07	0.07	0.02	0.02	0.01									0.08
	-1 1/2														0.00	0.00												0.00
	-1 3/4																											
	-2																											
TOTAL										0.11	0.96	7.87	115.54	2633.44	2646.56	121.74	8.02	1.09	0.26	0.04								

Table 6. 31-foot MCO (FRA Class 7 track)

CLASS 7 31 ft MCO		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													TOTAL
		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	
Upward surface deviation exceeding:	2																											
	1 3/4																											
	1 1/2																											
	1 1/4																											
	1												0.02	0.07	0.00													0.07
	7/8												0.06	0.18	0.06	0.01												0.24
	3/4											0.01	0.17	0.54	0.34	0.05	0.00											0.88
	5/8								0.00	0.01	0.02	0.06	0.36	1.57	0.99	0.10	0.01											2.56
	1/2								0.01	0.01	0.03	0.17	0.92	4.69	2.90	0.25	0.02											7.59
	3/8								0.01	0.01	0.05	0.37	2.63	13.19	8.92	0.82	0.10	0.01										22.11
	1/4								0.01	0.03	0.16	0.77	6.48	42.65	30.73	2.62	0.34	0.05	0.02	0.01	0.01							73.38
	1/8								0.01	0.07	0.29	1.61	15.13	172.48	142.67	8.49	0.82	0.15	0.10	0.04	0.03	0.01						315.15
	0							0.00	0.03	0.13	0.55	2.80	39.41	1376.56	1323.67	33.10	1.80	0.29	0.13	0.05	0.04	0.02	0.00					2700.23
Downward surface deviation exceeding:	0								0.03	0.16	0.42	1.93	31.22	1253.03	1326.74	41.21	3.27	0.50	0.13	0.05	0.01	0.01	0.00					2579.77
	- 1/8								0.01	0.08	0.25	1.00	9.89	135.97	174.91	18.22	2.23	0.35	0.10	0.03	0.01	0.00						310.87
	- 1/4								0.01	0.05	0.13	0.47	4.15	34.67	51.86	9.66	1.33	0.21	0.07	0.02								86.53
	- 3/8								0.01	0.03	0.07	0.22	1.95	13.20	21.27	5.23	0.80	0.15	0.05	0.01								34.46
	- 1/2								0.01	0.02	0.04	0.11	0.87	5.40	9.74	2.72	0.46	0.11	0.04	0.01								15.14
	- 5/8								0.01	0.02	0.03	0.05	0.37	2.25	4.63	1.41	0.20	0.05	0.02	0.01								6.87
	- 3/4								0.01	0.02	0.02	0.03	0.15	0.92	2.16	0.80	0.10	0.02	0.01									3.08
	- 7/8								0.01	0.02	0.02	0.02	0.06	0.33	0.92	0.35	0.05	0.00										1.25
	-1								0.00	0.01	0.01	0.01	0.02	0.13	0.37	0.16	0.02	0.00										0.50
	-1 1/4													0.02	0.07	0.03	0.00											0.08
	-1 1/2																											
	-1 3/4																											
	-2																											
TOTAL								0.00	0.06	0.29	0.97	4.73	70.63	2629.59	2650.41	74.31	5.08	0.79	0.26	0.10	0.05	0.02	0.01					

Table 7. 31-foot MCO (FRA Class 8 track)

CLASS 8 31 ft MCO		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:														TOTAL
		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	
Upward surface deviation exceeding:	2																											
	1 3/4																											
	1 1/2																											
	1 1/4																											
	1																											
	7/8																											
	3/4											0.00	0.02	0.03														0.03
	5/8											0.01	0.07	0.20	0.08													0.28
	1/2											0.01	0.21	1.14	0.54	0.02												1.68
	3/8											0.05	0.84	5.26	3.07	0.19	0.01	0.00										8.33
	1/4										0.01	0.17	2.51	20.64	14.42	0.99	0.10	0.02										35.06
	1/8										0.02	0.48	7.66	109.05	87.36	4.38	0.30	0.06	0.01									196.40
	0										0.09	1.06	26.30	1408.23	1287.45	22.27	0.67	0.09	0.01	0.01								2695.68
Downward surface deviation exceeding:	0									0.03	0.12	0.86	21.33	1223.17	1361.16	30.35	1.23	0.05	0.01	0.01								2584.32
	- 1/8									0.02	0.08	0.41	5.52	85.06	115.42	10.29	0.74	0.02	0.00									200.47
	- 1/4									0.01	0.03	0.14	1.79	18.18	28.48	4.70	0.40	0.01										46.66
	- 3/8										0.01	0.03	0.60	5.99	10.69	2.34	0.22	0.01										16.68
	- 1/2												0.26	2.26	4.43	1.22	0.13	0.01										6.68
	- 5/8												0.07	0.70	1.62	0.52	0.04											2.32
	- 3/4												0.03	0.15	0.43	0.15	0.01											0.57
	- 7/8												0.02	0.03	0.04	0.02												0.07
	-1																											
	-1 1/4																											
	-1 1/2																											
	-1 3/4																											
	-2																											
TOTAL										0.03	0.21	1.92	47.64	2631.40	2648.60	52.62	1.90	0.14	0.02	0.01								

62-foot MCO

Table 8. 62-foot MCO (FRA Class 2 track)

CLASS 2		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													
62 ft MCO		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	TOTAL
Upward surface deviation exceeding:	2																											
	1 3/4																											
	1 1/2												0.06	0.06														0.06
	1 1/4												0.12	0.17	0.06	0.04												0.23
	1									0.04	0.19	0.31	0.63	0.97	0.65	0.56	0.24	0.03	0.01									1.62
	7/8									0.09	0.29	0.63	1.46	2.20	1.55	1.10	0.42	0.10	0.07	0.01								3.75
	3/4				0.01	0.02	0.04	0.04	0.09	0.25	0.58	1.38	2.96	5.07	3.78	2.07	0.80	0.26	0.17	0.01								8.85
	5/8				0.04	0.15	0.23	0.27	0.33	0.64	1.27	2.67	5.51	10.19	7.80	3.94	1.63	0.71	0.44	0.16	0.12	0.12	0.02					17.98
	1/2				0.06	0.20	0.37	0.49	0.63	1.19	2.10	4.37	10.66	21.55	16.84	7.99	3.41	1.74	0.95	0.46	0.38	0.28	0.04					38.39
	3/8				0.07	0.24	0.42	0.75	1.17	2.36	4.39	8.62	22.29	50.06	38.55	17.08	7.25	4.23	2.53	1.16	0.71	0.46	0.10					88.60
	1/4				0.07	0.41	0.75	1.38	2.77	5.23	10.04	20.01	49.97	132.12	114.22	41.46	17.27	9.72	5.46	2.56	1.47	0.87	0.41	0.15	0.10	0.03		246.34
	1/8				0.10	0.59	1.22	2.52	5.15	10.30	22.07	46.82	128.30	430.26	404.89	122.43	50.33	26.78	14.57	7.23	3.55	1.72	0.79	0.31	0.12	0.05		835.15
	0			0.04	0.27	1.03	2.54	5.47	11.54	24.94	54.44	118.64	331.19	1,360.57	1,324.92	329.48	128.40	64.93	32.69	15.44	7.09	2.83	1.05	0.36	0.16	0.09		2,685.49
Downward surface deviation exceeding:	0		0.10	0.19	0.40	1.27	3.10	6.71	14.06	29.75	58.21	114.08	312.84	1,270.79	1,323.71	321.79	105.43	49.67	23.12	10.15	4.57	1.86	0.63	0.19	0.08	0.01		2,594.51
	- 1/8				0.09	0.47	1.06	2.52	5.16	11.12	21.50	42.06	115.98	389.31	429.86	134.38	44.94	20.31	9.77	4.37	1.91	0.74	0.33	0.14	0.03			819.17
	- 1/4				0.07	0.17	0.31	0.82	1.66	3.48	7.06	14.98	40.76	115.64	142.26	55.08	19.08	8.46	4.23	1.86	0.76	0.33	0.18	0.09				257.89
	- 3/8				0.04	0.07	0.07	0.25	0.61	1.61	2.97	6.31	16.28	43.06	58.48	26.64	9.94	4.60	2.54	0.99	0.41	0.24	0.13	0.07				101.54
	- 1/2					0.01	0.02	0.04	0.21	0.60	1.14	3.01	7.98	20.09	28.99	14.79	5.62	2.76	1.35	0.53	0.23	0.16	0.09	0.05				49.08
	- 5/8					0.01	0.01	0.01	0.05	0.28	0.63	1.72	4.45	10.05	15.76	8.67	3.38	1.48	0.69	0.27	0.10	0.09	0.04					25.81
	- 3/4								0.01	0.05	0.18	0.70	2.36	5.31	9.15	5.50	2.07	0.88	0.45	0.19	0.07	0.06	0.04					14.46
	- 7/8										0.03	0.39	1.25	3.08	5.54	3.26	1.22	0.38	0.19	0.09								8.62
	-1										0.01	0.18	0.66	1.70	3.31	1.97	0.69	0.16	0.04	0.01								5.01
	-1 1/4											0.01	0.07	0.31	1.01	0.64	0.25	0.04	0.01									1.32
	-1 1/2													0.07	0.19	0.05												0.26
	-1 3/4													0.02														0.02
	-2																											
TOTAL			0.10	0.23	0.67	2.31	5.64	12.18	25.60	54.69	112.65	232.72	644.02	2,631.36	2,648.64	651.28	233.83	114.60	55.81	25.59	11.66	4.69	1.69	0.55	0.24	0.10		

Table 9. 62-foot MCO (FRA Class 3 track)

CLASS 3		Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													TOTAL
62 ft MCO		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	
Upward surface deviation exceeding:	2 1/4								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											0.00
	2						0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00										0.02
	1 3/4						0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00					0.07
	1 1/2		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.10	0.14	0.10	0.06	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00			0.24
	1 1/4		0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.05	0.10	0.20	0.35	0.52	0.39	0.23	0.13	0.06	0.03	0.01	0.01	0.01	0.00	0.00	0.00			0.92
	1		0.00	0.00	0.01	0.02	0.03	0.06	0.10	0.19	0.36	0.69	1.28	2.04	1.54	0.85	0.43	0.19	0.09	0.05	0.03	0.02	0.01	0.00	0.00	0.00		3.58
	7/8		0.00	0.00	0.01	0.03	0.05	0.09	0.17	0.33	0.65	1.27	2.47	4.14	3.08	1.60	0.76	0.35	0.17	0.09	0.05	0.03	0.02	0.00	0.00	0.00		7.22
	3/4		0.00	0.00	0.01	0.04	0.08	0.15	0.28	0.57	1.15	2.35	4.84	8.55	6.27	3.07	1.38	0.63	0.30	0.15	0.08	0.05	0.03	0.01	0.00	0.00		14.82
	5/8		0.00	0.00	0.02	0.06	0.12	0.23	0.44	0.91	1.96	4.33	9.52	17.96	13.33	6.08	2.55	1.11	0.51	0.25	0.13	0.08	0.04	0.01	0.00	0.00		31.29
	1/2		0.00	0.01	0.02	0.08	0.17	0.35	0.69	1.46	3.28	7.83	18.94	38.84	29.63	12.33	4.77	1.96	0.87	0.42	0.21	0.12	0.07	0.01	0.00	0.00		68.47
	3/8		0.00	0.01	0.03	0.13	0.26	0.52	1.08	2.32	5.52	14.31	38.91	88.94	70.54	26.43	9.24	3.57	1.52	0.72	0.37	0.21	0.11	0.03	0.01	0.00		159.47
	1/4		0.00	0.01	0.05	0.19	0.39	0.79	1.65	3.76	9.31	26.44	82.37	218.51	181.91	59.66	18.40	6.56	2.68	1.22	0.61	0.33	0.18	0.04	0.01	0.00	0.00	400.42
	1/8	0.00	0.00	0.02	0.08	0.29	0.57	1.17	2.51	5.95	15.56	48.70	177.76	571.41	504.33	140.98	37.73	12.20	4.65	2.02	0.96	0.50	0.27	0.07	0.02	0.00	0.00	1075.74
	0	0.00	0.01	0.02	0.10	0.40	0.79	1.65	3.68	8.99	24.76	83.69	351.91	1395.56	1302.55	305.68	71.29	21.00	7.54	3.14	1.44	0.73	0.39	0.11	0.03	0.01	0.00	2698.11
Downward surface deviation exceeding:	0	0.00	0.01	0.03	0.10	0.36	0.70	1.46	3.20	7.65	21.04	70.63	298.97	1241.36	1340.54	346.32	84.76	25.73	9.45	4.00	1.89	0.97	0.55	0.19	0.06	0.02	0.01	2581.89
	- 1/8	0.00	0.01	0.02	0.07	0.24	0.47	0.96	2.06	4.76	12.30	37.88	139.48	481.36	554.73	179.61	51.21	16.98	6.61	2.90	1.40	0.73	0.42	0.14	0.05	0.01	0.00	1036.10
	- 1/4	0.00	0.00	0.02	0.05	0.16	0.32	0.62	1.31	2.92	7.05	19.68	62.69	183.97	226.63	89.34	29.96	10.96	4.51	2.04	1.00	0.53	0.31	0.11	0.03	0.01	0.00	410.60
	- 3/8	0.00	0.00	0.01	0.03	0.10	0.21	0.40	0.82	1.78	4.08	10.58	30.12	78.27	102.13	46.51	17.87	7.08	3.06	1.42	0.70	0.38	0.22	0.08	0.02	0.01	0.00	180.40
	- 1/2	0.00	0.00	0.01	0.02	0.07	0.13	0.26	0.52	1.11	2.42	5.90	15.41	36.57	50.21	25.40	10.89	4.62	2.08	0.98	0.49	0.27	0.15	0.05	0.02	0.01	0.00	86.78
	- 5/8	0.00	0.00	0.00	0.01	0.04	0.09	0.17	0.33	0.68	1.43	3.38	8.19	18.20	26.41	14.40	6.70	3.01	1.40	0.68	0.34	0.18	0.10	0.03	0.01	0.00	0.00	44.61
	- 3/4	0.00	0.00	0.00	0.01	0.03	0.05	0.10	0.21	0.41	0.84	1.93	4.47	9.53	14.55	8.40	4.19	1.96	0.95	0.46	0.23	0.13	0.07	0.02	0.01	0.00	0.00	24.08
	- 7/8		0.00	0.00	0.01	0.02	0.03	0.07	0.13	0.25	0.51	1.13	2.50	5.15	8.13	4.91	2.58	1.25	0.62	0.31	0.16	0.08	0.05	0.01	0.00	0.00	0.00	13.28
	-1			0.00	0.00	0.01	0.02	0.04	0.08	0.15	0.30	0.65	1.39	2.81	4.62	2.90	1.59	0.80	0.41	0.21	0.11	0.06	0.03	0.01	0.00	0.00		7.42
	-1 1/4				0.00	0.00	0.01	0.01	0.03	0.05	0.10	0.22	0.44	0.84	1.49	0.98	0.59	0.31	0.17	0.09	0.05	0.02	0.01	0.00	0.00			2.33
	-1 1/2				0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.13	0.25	0.45	0.30	0.19	0.10	0.05	0.03	0.01	0.01	0.00	0.00	0.00			0.71
	-1 3/4							0.00	0.00	0.00	0.01	0.02	0.03	0.07	0.13	0.09	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00			0.20
	-2							0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00						0.05
	-2 1/4									0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00							0.01
TOTAL		0.00	0.02	0.06	0.20	0.76	1.49	3.11	6.88	16.64	45.80	154.33	650.88	2636.92	2643.08	652.00	156.05	46.73	16.99	7.14	3.33	1.70	0.94	0.30	0.09	0.03	0.01	

Table 10. 62-foot MCO (FRA Class 4 track)

CLASS 4	62 ft MCO	Inward alignment deviation exceeding: -2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	Outward alignment deviation exceeding: 0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	TOTAL
Upward surface deviation exceeding:	2										0.00	0.00	0.00	0.00	0.00	0.00	0.00												0.00
	1 3/4						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.01
	1 1/2						0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00					0.08
	1 1/4				0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.12	0.20	0.15	0.08	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00				0.36
	1				0.00	0.00	0.00	0.01	0.02	0.05	0.11	0.25	0.52	0.94	0.71	0.34	0.14	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00			1.65
	7/8				0.00	0.00	0.01	0.02	0.04	0.09	0.21	0.48	1.07	2.03	1.52	0.69	0.27	0.10	0.05	0.02	0.01	0.00	0.00	0.00	0.00			3.55
	3/4			0.00	0.00	0.00	0.01	0.03	0.07	0.16	0.38	0.94	2.21	4.45	3.42	1.46	0.55	0.21	0.09	0.04	0.02	0.01	0.00	0.00	0.00			7.87
	5/8			0.00	0.00	0.01	0.02	0.05	0.12	0.29	0.71	1.82	4.61	9.96	7.81	3.11	1.10	0.41	0.16	0.07	0.03	0.01	0.00	0.00	0.00			17.77
	1/2			0.00	0.00	0.01	0.03	0.08	0.20	0.49	1.27	3.48	9.75	23.22	18.57	6.70	2.19	0.77	0.30	0.12	0.05	0.02	0.01	0.00	0.00	0.00		41.80
	3/8		0.00	0.00	0.00	0.02	0.05	0.13	0.32	0.82	2.23	6.56	21.12	57.91	47.83	15.06	4.33	1.43	0.53	0.21	0.09	0.04	0.01	0.00	0.00	0.00		105.74
	1/4		0.00	0.00	0.01	0.03	0.08	0.20	0.51	1.32	3.73	12.22	47.56	159.32	137.23	35.87	8.64	2.58	0.91	0.35	0.14	0.06	0.02	0.01	0.00	0.00	0.00	296.55
	1/8		0.00	0.00	0.01	0.05	0.12	0.30	0.76	2.04	6.11	22.65	112.04	486.09	441.11	91.82	17.64	4.61	1.52	0.56	0.22	0.09	0.04	0.01	0.00	0.00	0.00	927.20
	0		0.00	0.00	0.01	0.07	0.18	0.43	1.09	2.99	9.48	39.63	243.60	1,379.74	1,314.59	218.04	34.14	7.86	2.41	0.86	0.33	0.13	0.06	0.01	0.00	0.00	0.00	2694.33
Downward surface deviation exceeding:	0	0.00	0.00	0.00	0.02	0.08	0.17	0.40	0.97	2.62	8.18	34.26	215.19	1,258.13	1,327.54	244.38	42.13	10.37	3.34	1.25	0.51	0.25	0.13	0.04	0.01	0.00	0.00	2585.67
	- 1/8	0.00	0.00	0.00	0.01	0.05	0.12	0.27	0.66	1.71	4.97	18.32	92.52	426.23	476.37	116.45	25.07	6.96	2.39	0.93	0.39	0.19	0.11	0.04	0.01	0.00	0.00	902.60
	- 1/4	0.00	0.00	0.00	0.01	0.04	0.08	0.18	0.42	1.07	2.91	9.44	38.24	141.32	168.38	53.02	14.37	4.51	1.64	0.65	0.27	0.14	0.08	0.03	0.01	0.00	0.00	309.70
	- 3/8	0.00	0.00	0.00	0.01	0.02	0.05	0.11	0.26	0.65	1.69	5.01	17.31	54.06	68.37	25.99	8.35	2.89	1.10	0.44	0.19	0.10	0.05	0.02	0.01	0.00	0.00	122.43
	- 1/2	0.00	0.00	0.00	0.00	0.01	0.03	0.07	0.16	0.39	0.98	2.74	8.46	23.57	31.19	13.47	4.85	1.81	0.72	0.30	0.13	0.07	0.04	0.01	0.00	0.00	0.00	54.76
	- 5/8	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.10	0.23	0.56	1.51	4.32	11.19	15.40	7.25	2.82	1.11	0.45	0.19	0.08	0.04	0.02	0.01	0.00	0.00	0.00	26.59
	- 3/4	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.14	0.32	0.85	2.28	5.59	7.91	3.96	1.64	0.67	0.28	0.12	0.05	0.03	0.01	0.00	0.00	0.00	0.00	13.50
	- 7/8			0.00	0.00	0.00	0.01	0.02	0.04	0.08	0.18	0.46	1.20	2.84	4.14	2.17	0.95	0.40	0.17	0.08	0.03	0.02	0.01	0.00	0.00	0.00		6.97
	-1				0.00	0.00	0.00	0.01	0.02	0.04	0.10	0.25	0.64	1.46	2.17	1.18	0.54	0.23	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00		3.63
	-1 1/4				0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.07	0.17	0.37	0.58	0.34	0.16	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00		0.95
	-1 1/2						0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.09	0.14	0.09	0.05	0.02	0.01	0.00	0.00	0.00	0.00					0.23
	-1 3/4							0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00						0.05
	-2								0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00						0.01
TOTAL		0.00	0.00	0.00	0.03	0.15	0.35	0.83	2.06	5.61	17.66	73.89	458.79	2,637.87	2,642.13	462.43	76.27	18.22	5.75	2.11	0.84	0.38	0.19	0.06	0.02	0.00	0.00	

Table 11. 62-foot MCO (FRA Class 5 track)

CLASS 5	62 ft MCO	Inward alignment deviation exceeding:													Outward alignment deviation exceeding:													TOTAL
		-2	-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	
Upward surface deviation exceeding:	2														0.00	0.00												0.00
	1 3/4										0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										0.00
	1 1/2										0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00										0.01
	1 1/4							0.00	0.00	0.00	0.01	0.01	0.02	0.04	0.03	0.01	0.00	0.00	0.00	0.00								0.07
	1						0.00	0.00	0.00	0.01	0.03	0.06	0.15	0.30	0.21	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00				0.51
	7/8						0.00	0.00	0.01	0.02	0.06	0.15	0.37	0.76	0.56	0.21	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00				1.31
	3/4					0.00	0.00	0.01	0.01	0.04	0.12	0.31	0.86	1.93	1.53	0.57	0.19	0.07	0.02	0.01	0.00	0.00	0.00	0.00				3.46
	5/8					0.00	0.00	0.01	0.03	0.09	0.24	0.66	2.01	5.01	4.11	1.41	0.43	0.14	0.05	0.02	0.01	0.00	0.00	0.00				9.12
	1/2				0.00	0.00	0.01	0.02	0.05	0.16	0.46	1.39	4.67	13.01	11.01	3.44	0.93	0.30	0.11	0.03	0.01	0.01	0.00	0.00	0.00			24.02
	3/8				0.00	0.00	0.01	0.03	0.09	0.28	0.86	2.86	11.00	36.05	31.68	8.52	2.04	0.59	0.20	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	67.73
	1/4		0.00	0.00	0.00	0.01	0.02	0.05	0.15	0.47	1.51	5.67	27.02	113.39	103.68	22.51	4.41	1.11	0.34	0.11	0.04	0.02	0.01	0.00	0.00	0.00	0.00	217.07
	1/8		0.00	0.00	0.00	0.01	0.03	0.09	0.25	0.76	2.57	11.09	71.38	409.77	388.39	63.96	9.62	2.08	0.59	0.18	0.07	0.03	0.01	0.01	0.00	0.00	0.00	798.16
	0		0.00	0.00	0.00	0.02	0.05	0.13	0.36	1.12	4.02	20.37	173.57	1365.85	1327.44	166.03	19.59	3.63	0.93	0.28	0.10	0.04	0.02	0.01	0.00	0.00	0.00	2693.29
Downward surface deviation exceeding:	0		0.00	0.00	0.01	0.03	0.06	0.14	0.36	1.06	3.78	19.46	165.37	1277.49	1309.22	181.52	23.64	4.65	1.24	0.42	0.18	0.10	0.07	0.04	0.02	0.00	0.00	2586.71
	- 1/8		0.00	0.00	0.01	0.02	0.04	0.10	0.25	0.70	2.33	10.27	67.16	382.01	403.61	78.09	13.34	3.06	0.88	0.31	0.14	0.08	0.06	0.04	0.01	0.00	0.00	785.62
	- 1/4		0.00	0.00	0.01	0.02	0.03	0.07	0.17	0.44	1.36	5.08	25.45	111.43	122.91	31.72	7.24	1.96	0.61	0.22	0.10	0.06	0.05	0.03	0.01	0.00	0.00	234.34
	- 3/8			0.00	0.00	0.01	0.02	0.04	0.10	0.27	0.77	2.60	10.79	38.57	44.52	14.31	4.03	1.23	0.41	0.16	0.08	0.05	0.03	0.02	0.01	0.00		83.08
	- 1/2				0.00	0.01	0.01	0.02	0.06	0.15	0.43	1.36	4.96	15.62	18.84	6.98	2.25	0.75	0.27	0.11	0.05	0.03	0.02	0.01	0.01	0.00		34.45
	- 5/8				0.00	0.00	0.01	0.01	0.04	0.09	0.25	0.72	2.39	6.98	8.72	3.59	1.28	0.44	0.16	0.07	0.03	0.02	0.01	0.01	0.00	0.00		15.70
	- 3/4				0.00	0.00	0.00	0.01	0.02	0.05	0.14	0.36	1.14	3.22	4.19	1.84	0.69	0.24	0.09	0.04	0.02	0.01	0.01	0.01	0.00	0.00		7.41
	- 7/8				0.00	0.00	0.00	0.00	0.01	0.03	0.07	0.18	0.55	1.50	2.02	0.94	0.38	0.14	0.06	0.02	0.01	0.01	0.01	0.00	0.00	0.00		3.52
	-1				0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.09	0.25	0.69	0.93	0.46	0.19	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.00			1.63
	-1 1/4					0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.11	0.19	0.11	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00			0.30
	-1 1/2									0.00	0.00	0.00	0.01	0.01	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00				0.04
	-1 3/4												0.00	0.00	0.00	0.00	0.00	0.00										0.01
	-2												0.00	0.00	0.00	0.00	0.00	0.00										0.00
TOTAL			0.00	0.00	0.01	0.05	0.11	0.27	0.72	2.18	7.81	39.82	338.93	2643.34	2636.66	347.55	43.24	8.29	2.16	0.70	0.28	0.14	0.09	0.05	0.02	0.00	0.00	

Table 12. 62-foot MCO (FRA Class 6 track)

CLASS 6 62 ft MCO		Inward alignment deviation exceeding:									Outward alignment deviation exceeding:									TOTAL
		-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	
Upward surface deviation exceeding:	2																			
	1 3/4																			
	1 1/2																			
	1 1/4									0.02										0.02
	1							0.01	0.01	0.06	0.07	0.04								0.12
	7/8							0.02	0.03	0.14	0.17	0.10	0.00							0.30
	3/4					0.03	0.07	0.17	0.27	0.70	0.62	0.31	0.10	0.01	0.01	0.00				1.32
	5/8					0.04	0.13	0.42	1.05	2.67	2.15	0.74	0.28	0.07	0.02	0.01				4.82
	1/2			0.00	0.01	0.07	0.46	1.34	3.32	8.45	6.53	2.23	0.75	0.17	0.04	0.01				14.99
	3/8			0.01	0.09	0.20	0.92	3.06	9.32	25.38	19.01	5.54	1.53	0.34	0.07	0.02				44.39
	1/4			0.03	0.15	0.40	1.54	5.86	22.20	76.12	57.87	13.32	3.27	0.81	0.24	0.12	0.03			133.99
	1/8			0.03	0.21	0.67	2.63	9.99	49.21	264.55	228.51	35.69	6.51	1.58	0.41	0.17	0.03			493.06
	0			0.03	0.26	1.06	3.99	16.66	119.94	1379.54	1335.69	106.94	12.63	2.61	0.56	0.21	0.03			2715.23
Downward surface deviation exceeding:	0			0.01	0.18	0.80	3.40	14.02	103.39	1255.79	1308.98	122.42	18.81	4.56	1.23	0.35	0.08			2564.77
	- 1/8			0.01	0.14	0.54	2.27	8.51	37.94	216.30	260.51	52.62	11.96	3.30	0.83	0.24	0.06			476.81
	- 1/4			0.01	0.11	0.37	1.56	5.26	17.31	64.54	87.11	27.12	8.11	2.45	0.60	0.19	0.06			151.65
	- 3/8			0.01	0.08	0.26	0.99	3.05	8.92	27.34	38.59	15.08	5.21	1.84	0.43	0.16	0.06			65.93
	- 1/2			0.01	0.07	0.18	0.58	1.61	4.47	12.42	19.13	8.55	3.22	1.30	0.35	0.13	0.05			31.55
	- 5/8				0.04	0.10	0.25	0.66	1.85	5.44	8.70	4.29	1.77	0.77	0.22	0.09	0.03			14.14
	- 3/4				0.03	0.04	0.08	0.21	0.64	2.05	4.27	2.30	1.04	0.50	0.15	0.06	0.02			6.32
	- 7/8							0.01	0.15	0.65	1.75	0.97	0.50	0.30	0.09	0.04	0.02			2.39
	-1								0.02	0.14	0.61	0.40	0.18	0.12	0.03	0.03	0.02			0.75
	-1 1/4								0.01	0.02	0.04	0.03								0.06
	-1 1/2										0.01	0.01								0.01
	-1 3/4																			
	-2																			
TOTAL				0.05	0.44	1.87	7.39	30.68	223.32	2635.33	2644.67	229.36	31.43	7.18	1.79	0.55	0.11			

Table 13. 62-foot MCO (FRA Class 7 track)

CLASS 7		Inward alignment deviation exceeding:									Outward alignment deviation exceeding:									
62 ft MCO		-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	TOTAL
Upward surface deviation exceeding:	2																			
	1 3/4																			
	1 1/2																			
	1 1/4										0.01	0.01	0.00							0.01
	1							0.03	0.03	0.05	0.07	0.06	0.05	0.03	0.03	0.02	0.02	0.01	0.01	0.12
	7/8						0.00	0.04	0.06	0.12	0.15	0.09	0.07	0.04	0.04	0.03	0.02	0.02	0.01	0.27
	3/4	0.00	0.02	0.02	0.02	0.02	0.03	0.09	0.20	0.40	0.35	0.17	0.10	0.04	0.04	0.03	0.03	0.02	0.02	0.75
	5/8	0.01	0.03	0.04	0.04	0.04	0.05	0.21	0.58	1.46	1.04	0.38	0.12	0.05	0.05	0.04	0.03	0.03	0.02	2.50
	1/2	0.01	0.03	0.05	0.05	0.05	0.08	0.42	1.44	4.68	3.41	0.93	0.20	0.05	0.05	0.04	0.03	0.03	0.02	8.09
	3/8	0.01	0.03	0.06	0.07	0.09	0.25	1.05	4.26	15.67	11.26	2.51	0.45	0.08	0.05	0.04	0.04	0.03	0.02	26.93
	1/4	0.01	0.04	0.07	0.10	0.16	0.55	2.52	11.40	53.07	38.98	6.50	1.12	0.21	0.06	0.05	0.04	0.03	0.02	92.05
	1/8	0.01	0.04	0.09	0.13	0.31	1.04	4.78	29.62	222.35	186.18	19.32	2.64	0.51	0.13	0.07	0.05	0.03	0.02	408.52
	0	0.01	0.04	0.09	0.16	0.49	1.72	8.32	80.17	1396.36	1315.80	68.03	6.03	1.05	0.23	0.09	0.05	0.03	0.02	2712.16
Downward surface deviation exceeding:	0		0.03	0.06	0.14	0.48	1.69	7.22	67.35	1235.91	1331.93	85.21	9.35	1.85	0.57	0.15	0.05	0.01		2567.84
	- 1/8		0.03	0.06	0.13	0.33	1.01	3.98	23.16	179.74	224.58	34.38	5.82	1.23	0.43	0.13	0.04	0.01		404.32
	- 1/4		0.03	0.06	0.10	0.22	0.60	1.91	9.21	45.33	66.05	16.77	3.52	0.90	0.31	0.12	0.03	0.01		111.38
	- 3/8		0.03	0.06	0.08	0.16	0.32	0.90	4.12	17.27	27.08	8.37	2.01	0.62	0.22	0.09	0.03	0.01		44.35
	- 1/2		0.03	0.05	0.07	0.14	0.20	0.53	2.00	7.28	11.69	4.17	1.11	0.38	0.13	0.06	0.03	0.01		18.97
	- 5/8		0.02	0.03	0.05	0.09	0.11	0.33	0.99	3.14	5.33	2.10	0.61	0.27	0.10	0.04	0.02	0.01		8.47
	- 3/4		0.01	0.03	0.03	0.06	0.07	0.21	0.55	1.37	2.40	1.10	0.37	0.18	0.08	0.02	0.02	0.01		3.77
	- 7/8		0.01	0.02	0.02	0.05	0.05	0.13	0.28	0.57	1.03	0.52	0.23	0.10	0.05	0.02	0.02	0.01		1.61
	-1		0.00	0.01	0.01	0.04	0.04	0.06	0.13	0.25	0.54	0.25	0.11	0.06	0.04	0.02	0.01	0.01		0.79
	-1 1/4				0.00	0.02	0.02	0.02	0.02	0.02	0.10	0.05	0.04	0.02	0.01	0.01	0.00			0.12
	-1 1/2					0.00	0.00	0.00	0.00	0.00										0.00
	-1 3/4																			
	-2																			
TOTAL		0.01	0.08	0.15	0.30	0.97	3.42	15.54	147.53	2632.27	2647.73	153.24	15.39	2.90	0.79	0.24	0.10	0.04	0.02	

Table 14. 62-foot MCO (FRA Class 8 track)

CLASS 8		Inward alignment deviation exceeding:									Outward alignment deviation exceeding:									
62 ft MCO		-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	TOTAL
Upward surface deviation exceeding:	2																			
	1 3/4																			
	1 1/2																			
	1 1/4																			
	1																			
	7/8																			
	3/4								0.00	0.00										0.00
	5/8							0.02	0.08	0.15	0.10	0.02								0.25
	1/2						0.01	0.12	0.29	0.92	0.57	0.12								1.49
	3/8						0.04	0.33	1.15	4.73	3.08	0.51	0.04							7.81
	1/4					0.00	0.11	0.81	4.57	23.70	15.66	2.15	0.22	0.03	0.01					39.36
	1/8					0.03	0.33	1.95	15.54	141.73	110.68	9.25	0.81	0.07	0.01					252.41
	0					0.09	0.74	4.28	49.24	1412.21	1300.21	40.14	2.73	0.26	0.05					2712.42
Downward surface deviation exceeding:	0			0.01	0.05	0.15	0.53	3.73	40.40	1217.13	1350.45	54.36	5.03	0.64	0.05					2567.58
	- 1/8			0.00	0.02	0.05	0.24	1.68	11.96	109.32	148.05	19.92	2.85	0.40	0.02					257.36
	- 1/4						0.05	0.59	4.04	21.92	35.65	8.97	1.73	0.27	0.02					57.57
	- 3/8						0.00	0.22	1.40	6.76	12.82	4.21	0.90	0.17	0.02					19.58
	- 1/2							0.07	0.49	2.42	5.04	1.94	0.42	0.08	0.01					7.46
	- 5/8							0.03	0.17	0.81	1.94	0.85	0.22	0.03						2.75
	- 3/4							0.02	0.06	0.23	0.63	0.28	0.10	0.01						0.86
	- 7/8							0.02	0.03	0.06	0.09	0.03	0.00							0.14
	-1									0.01	0.01									0.02
	-1 1/4																			
	-1 1/2																			
	-1 3/4																			
	-2																			
TOTAL				0.01	0.05	0.24	1.27	8.02	89.64	2629.34	2650.66	94.50	7.76	0.90	0.10					

124-foot MCO

Table 15. 124-foot MCO (FRA Class 6 track)

CLASS 6	124 ft MCO	Inward alignment deviation exceeding:												Outward alignment deviation exceeding:												TOTAL
		-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	
Upward surface deviation exceeding:	1 3/4																									
	1 1/2										0.01	0.04	0.04	0.07	0.07	0.01										0.12
	1 1/4							0.06	0.07	0.11	0.24	0.38	0.38	0.29	0.28	0.08										0.68
	1					0.01	0.03	0.10	0.25	0.47	0.83	1.63	2.01	1.67	1.20	0.54	0.17	0.10	0.10	0.08	0.03					3.68
	7/8					0.03	0.10	0.23	0.54	0.96	1.65	2.89	3.90	3.60	2.29	1.19	0.51	0.27	0.17	0.14	0.04					7.49
	3/4					0.04	0.18	0.45	0.95	1.77	3.05	5.38	8.01	7.11	4.07	2.08	0.94	0.41	0.25	0.19	0.06					15.12
	5/8				0.03	0.11	0.28	0.71	1.62	3.24	5.63	10.48	17.24	14.89	7.73	3.78	1.95	0.97	0.52	0.29	0.10					32.13
	1/2			0.01	0.07	0.19	0.43	1.25	2.70	5.55	10.41	20.50	37.12	32.01	15.21	7.44	3.69	1.91	0.91	0.46	0.12					69.12
	3/8			0.04	0.14	0.30	0.62	1.83	4.06	9.02	18.70	40.45	80.87	70.86	31.64	14.86	6.97	3.73	1.56	0.70	0.24	0.02				151.73
	1/4			0.05	0.16	0.36	0.88	2.62	6.07	14.40	33.09	79.60	186.56	168.69	68.47	29.70	12.92	6.06	2.53	0.90	0.36	0.07				355.25
	1/8			0.06	0.22	0.48	1.12	4.09	9.77	23.02	58.72	165.08	497.79	477.56	157.98	58.47	22.70	9.25	3.57	1.19	0.51	0.15				975.35
	0			0.07	0.31	0.66	1.58	6.03	14.82	37.71	106.30	350.40	1,361.09	1,334.23	345.76	106.82	36.99	13.92	5.11	1.66	0.63	0.24				2,695.33
Downward surface deviation exceeding:	0		0.00	0.03	0.14	0.59	1.47	4.02	10.87	34.40	105.14	336.60	1,272.80	1,311.87	344.25	100.60	35.26	12.69	5.22	1.96	0.83	0.30	0.04			2,584.67
	- 1/8		0.00	0.02	0.12	0.51	1.22	3.01	7.12	20.57	56.24	154.52	458.10	485.92	165.28	56.28	20.93	7.70	3.44	1.55	0.67	0.25	0.04			944.02
	- 1/4			0.01	0.09	0.40	1.00	2.03	4.49	12.01	29.69	71.05	169.29	190.32	81.42	32.69	13.57	5.37	2.43	1.08	0.42	0.20	0.04			359.61
	- 3/8				0.07	0.24	0.69	1.40	2.77	7.11	16.07	36.04	75.49	90.89	45.48	20.32	9.54	3.97	1.78	0.78	0.32	0.15	0.04			166.38
	- 1/2				0.05	0.15	0.42	0.90	1.77	4.16	8.85	18.87	37.61	46.97	25.49	12.71	6.52	2.89	1.27	0.55	0.22	0.08	0.03			84.58
	- 5/8				0.04	0.10	0.26	0.59	1.11	2.25	4.81	9.52	18.58	25.02	14.66	7.99	4.08	1.85	0.90	0.37	0.14	0.06	0.02			43.60
	- 3/4				0.02	0.04	0.12	0.32	0.64	1.18	2.45	4.69	9.03	13.57	8.43	4.76	2.38	1.13	0.58	0.26	0.12	0.04	0.01			22.60
	- 7/8				0.01	0.01	0.03	0.12	0.27	0.47	1.06	2.17	4.19	7.03	4.49	2.63	1.33	0.62	0.29	0.14	0.10	0.04	0.01			11.22
	-1						0.00	0.07	0.14	0.18	0.46	0.97	1.83	3.37	2.28	1.31	0.65	0.30	0.18	0.10	0.07	0.04	0.01			5.20
	-1 1/4									0.00	0.03	0.11	0.25	0.58	0.37	0.21	0.11	0.07	0.07	0.05	0.05	0.04	0.01			0.83
	-1 1/2											0.01	0.03	0.07	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.01			0.10
	-1 3/4													0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01			0.03
TOTAL			0.00	0.10	0.44	1.25	3.05	10.05	25.69	72.11	211.44	686.99	2,633.90	2,646.10	690.00	207.42	72.24	26.61	10.33	3.62	1.46	0.54	0.04			

Table 16. 124-foot MCO (FRA Class 7 track)

CLASS 7 124 ft MCO		Inward alignment deviation exceeding:												Outward alignment deviation exceeding:												TOTAL
		-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	TOTAL
Upward surface deviation exceeding:	1 3/4																									
	1 1/2													0.02												0.02
	1 1/4											0.01	0.16	0.18	0.01											0.33
	1							0.01	0.01	0.01	0.04	0.25	0.66	0.68	0.13	0.03	0.01	0.01								1.34
	7/8							0.02	0.05	0.10	0.28	0.86	1.62	1.42	0.49	0.23	0.16	0.11	0.03	0.01						3.04
	3/4							0.04	0.11	0.27	0.69	2.10	4.43	3.71	1.53	0.65	0.33	0.17	0.07	0.01						8.14
	5/8					0.01	0.02	0.09	0.21	0.53	1.71	5.07	10.58	9.00	3.69	1.40	0.63	0.29	0.12	0.02	0.01					19.58
	1/2					0.01	0.04	0.15	0.39	1.15	3.77	11.06	25.39	21.08	8.32	2.86	1.27	0.55	0.19	0.06	0.01					46.47
	3/8					0.07	0.14	0.40	1.01	2.68	7.82	24.12	61.48	52.43	19.24	6.36	2.49	0.96	0.40	0.14	0.02					113.91
	1/4				0.02	0.16	0.31	0.79	1.85	5.02	16.20	54.10	160.82	144.94	46.80	14.44	4.67	1.59	0.75	0.29	0.09	0.01				305.76
	1/8				0.06	0.26	0.51	1.29	3.23	9.23	31.60	125.24	471.32	443.46	117.48	30.64	8.37	2.88	1.26	0.50	0.18	0.02				914.78
	0				0.12	0.42	0.81	1.89	5.22	15.58	58.84	276.76	1,363.27	1,331.04	271.51	58.09	14.89	5.17	2.11	0.89	0.37	0.15				2,694.31
Downward surface deviation exceeding:	0				0.05	0.30	0.74	1.74	4.73	15.39	58.65	272.98	1,268.83	1,316.86	279.61	60.75	16.34	5.06	1.76	0.74	0.38	0.18	0.02			2,585.69
	- 1/8					0.09	0.34	0.94	2.80	9.26	32.23	122.60	431.13	461.59	129.92	34.04	10.45	3.43	1.23	0.52	0.25	0.11	0.02			892.72
	- 1/4					0.06	0.25	0.61	1.78	5.41	16.56	51.37	147.03	166.65	61.16	19.29	6.84	2.51	0.94	0.39	0.17	0.06	0.01			313.68
	- 3/8					0.05	0.17	0.39	1.08	2.93	8.46	24.20	61.05	72.42	31.38	11.33	4.31	1.68	0.64	0.31	0.12	0.03	0.00			133.47
	- 1/2					0.03	0.12	0.26	0.66	1.76	4.39	11.76	28.17	34.86	16.76	6.44	2.49	1.00	0.38	0.22	0.08	0.02				63.03
	- 5/8					0.03	0.09	0.19	0.35	0.80	2.19	5.68	13.28	17.36	8.59	3.44	1.31	0.55	0.21	0.10	0.04					30.64
	- 3/4					0.03	0.08	0.14	0.20	0.40	1.07	2.83	6.03	8.93	4.80	2.02	0.82	0.34	0.14	0.08	0.04					14.96
	- 7/8					0.03	0.06	0.09	0.12	0.18	0.51	1.27	2.64	4.13	2.39	1.13	0.50	0.20	0.10	0.06	0.04					6.77
	-1					0.02	0.05	0.07	0.08	0.09	0.25	0.56	1.11	1.80	1.06	0.55	0.28	0.12	0.06	0.05	0.04					2.91
	-1 1/4						0.01	0.02	0.02	0.02	0.06	0.09	0.20	0.31	0.20	0.11	0.05	0.01	0.01	0.01	0.01					0.51
	-1 1/2										0.02	0.03	0.04	0.04	0.03	0.01										0.08
	-1 3/4										0.00	0.00	0.00													0.00
TOTAL					0.17	0.72	1.55	3.64	9.95	30.98	117.48	549.74	2,632.09	2,647.91	551.12	118.84	31.23	10.23	3.87	1.63	0.75	0.33	0.02			

Table 17. 124-foot MCO (FRA Class 8 track)

CLASS 8		Inward alignment deviation exceeding:												Outward alignment deviation exceeding:												
124 ft MCO		-1 3/4	-1 1/2	-1 1/4	-1	- 7/8	- 3/4	- 5/8	- 1/2	- 3/8	- 1/4	- 1/8	0	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	TOTAL
Upward surface deviation exceeding:	1 3/4																									
	1 1/2																									
	1 1/4																									
	1												0.03	0.05												0.09
	7/8									0.00	0.01	0.04	0.20	0.13	0.01											0.33
	3/4									0.02	0.16	0.38	0.75	0.42	0.12											1.17
	5/8								0.01	0.08	0.33	0.98	2.11	1.40	0.46	0.04	0.02									3.50
	1/2							0.08	0.15	0.36	0.99	3.14	7.06	5.37	1.80	0.31	0.11	0.01								12.42
	3/8							0.13	0.28	0.93	2.98	9.07	23.41	18.55	6.04	1.41	0.45	0.06	0.02							41.96
	1/4						0.04	0.21	0.51	1.80	6.62	23.38	79.02	66.85	17.73	4.17	1.31	0.28	0.13	0.00						145.87
	1/8						0.05	0.31	0.91	3.63	13.53	63.55	328.19	292.68	56.86	10.29	2.76	0.55	0.21	0.04						620.87
	0						0.07	0.40	1.25	5.41	24.70	166.08	1,380.23	1,311.40	157.17	21.38	4.57	0.88	0.28	0.09	0.02					2,691.63
Downward surface deviation exceeding:	0						0.09	0.35	1.33	4.73	23.47	157.84	1,250.27	1,338.10	170.07	25.45	5.92	1.40	0.37	0.08	0.04					2,588.37
	- 1/8						0.03	0.19	0.85	2.85	11.97	57.63	281.74	322.28	69.86	14.42	4.18	1.04	0.26	0.05	0.01					604.02
	- 1/4							0.09	0.49	1.65	5.60	20.97	72.25	88.88	29.99	8.61	3.05	0.74	0.15	0.03						161.13
	- 3/8							0.06	0.31	0.91	2.75	8.68	25.12	33.88	14.50	5.21	2.09	0.54	0.11	0.01						59.00
	- 1/2							0.03	0.12	0.45	1.31	3.56	9.51	14.38	7.33	3.01	1.37	0.39	0.09							23.90
	- 5/8							0.01	0.08	0.24	0.69	1.60	4.12	6.19	3.69	1.74	0.78	0.27	0.07							10.31
	- 3/4							0.01	0.03	0.16	0.44	0.92	2.00	2.49	1.63	0.85	0.40	0.12	0.04							4.49
	- 7/8								0.02	0.12	0.30	0.48	0.91	0.87	0.66	0.40	0.20	0.06	0.03							1.79
	-1								0.02	0.10	0.18	0.24	0.36	0.33	0.24	0.16	0.08	0.03	0.01							0.69
	-1 1/4									0.00	0.01	0.02	0.08	0.01	0.01	0.01										0.09
	-1 1/2																									
	-1 3/4																									
TOTAL							0.16	0.75	2.58	10.14	48.17	323.92	2,630.50	2,649.50	327.24	46.83	10.49	2.28	0.64	0.16	0.06					

Appendix C.
Power Spectral Density Plots

This appendix contains the PSD plots discussed in Section 6.1 and Section 6.2.

Gage

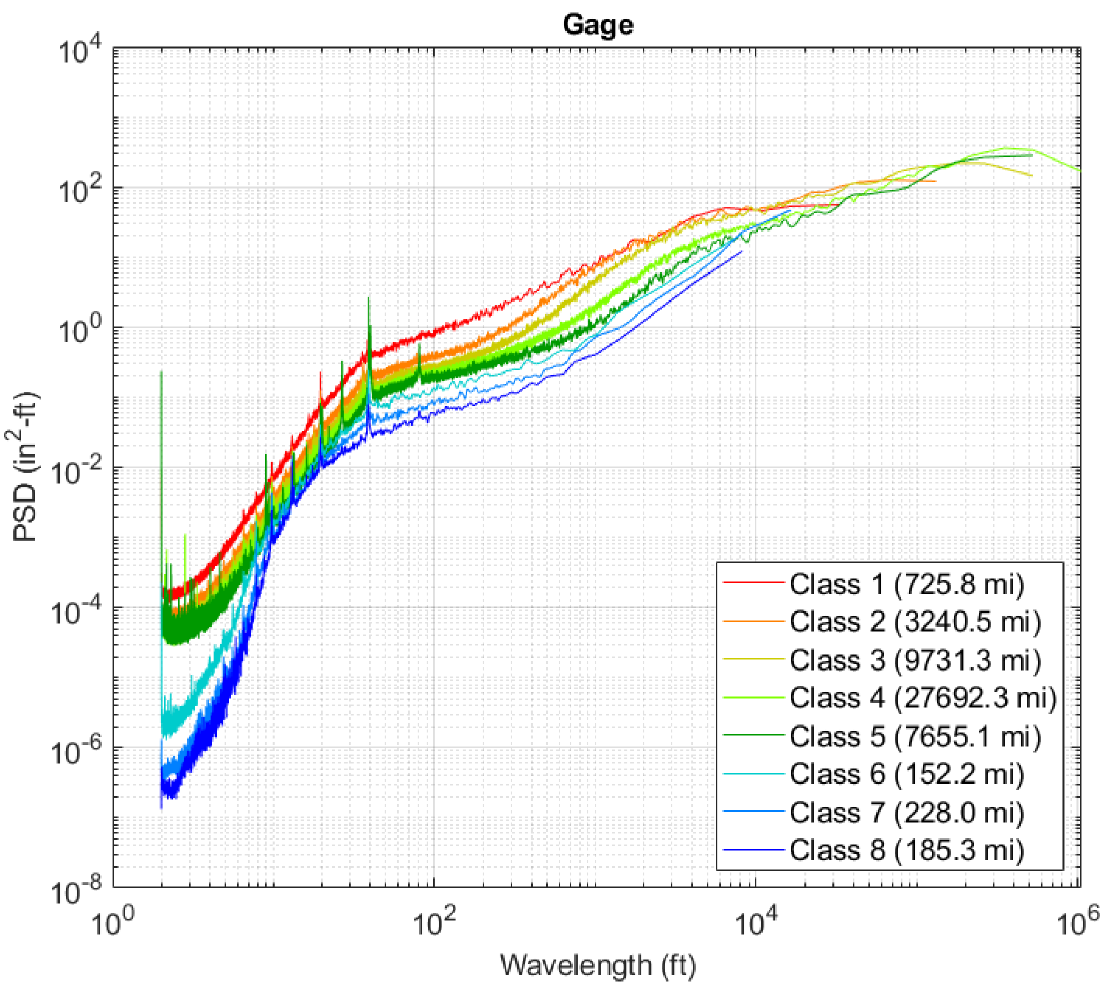

Figure 1. PSD plot of gage by FRA track class

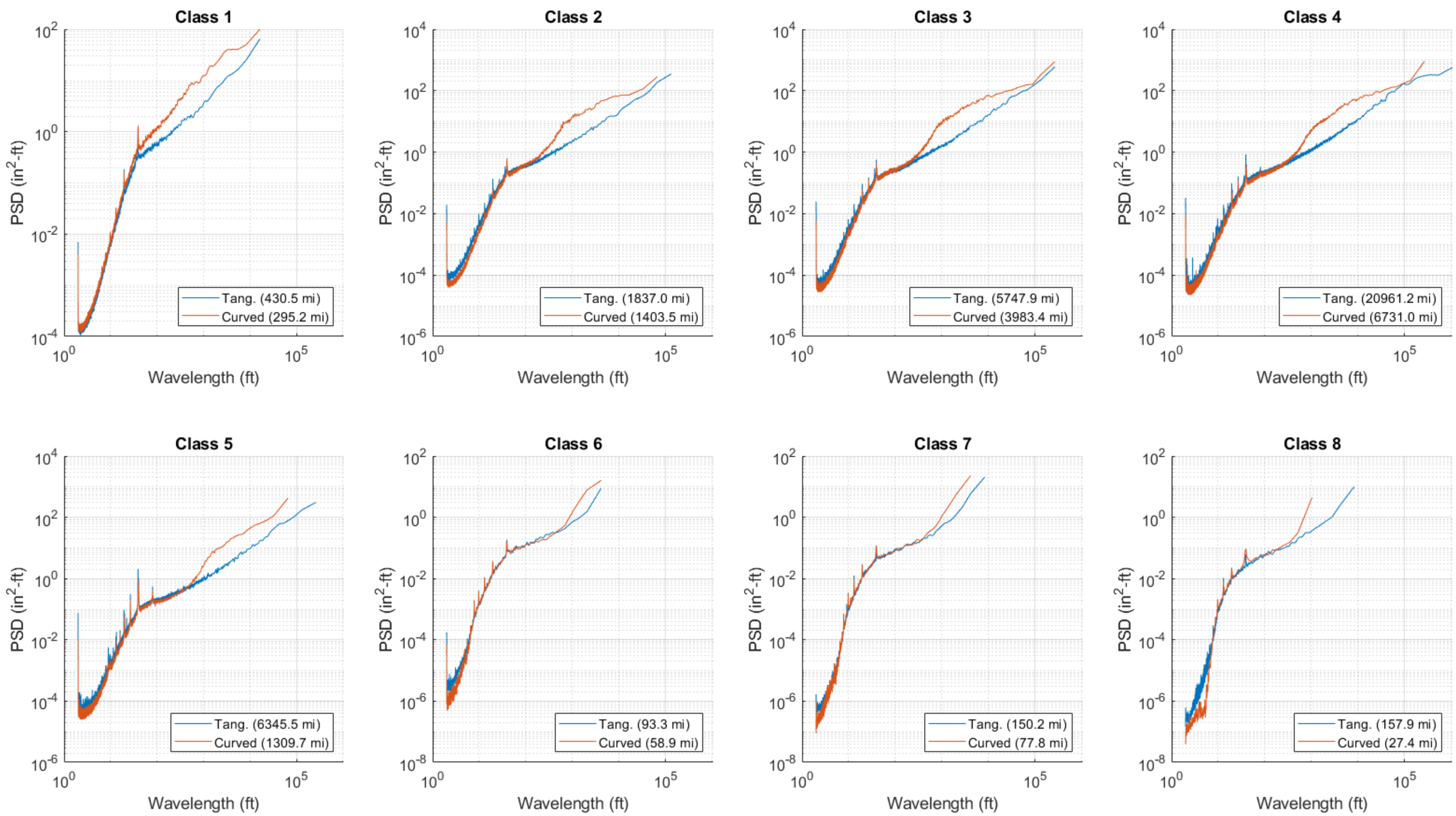

Figure 2. PSD plot of gage by track curvature

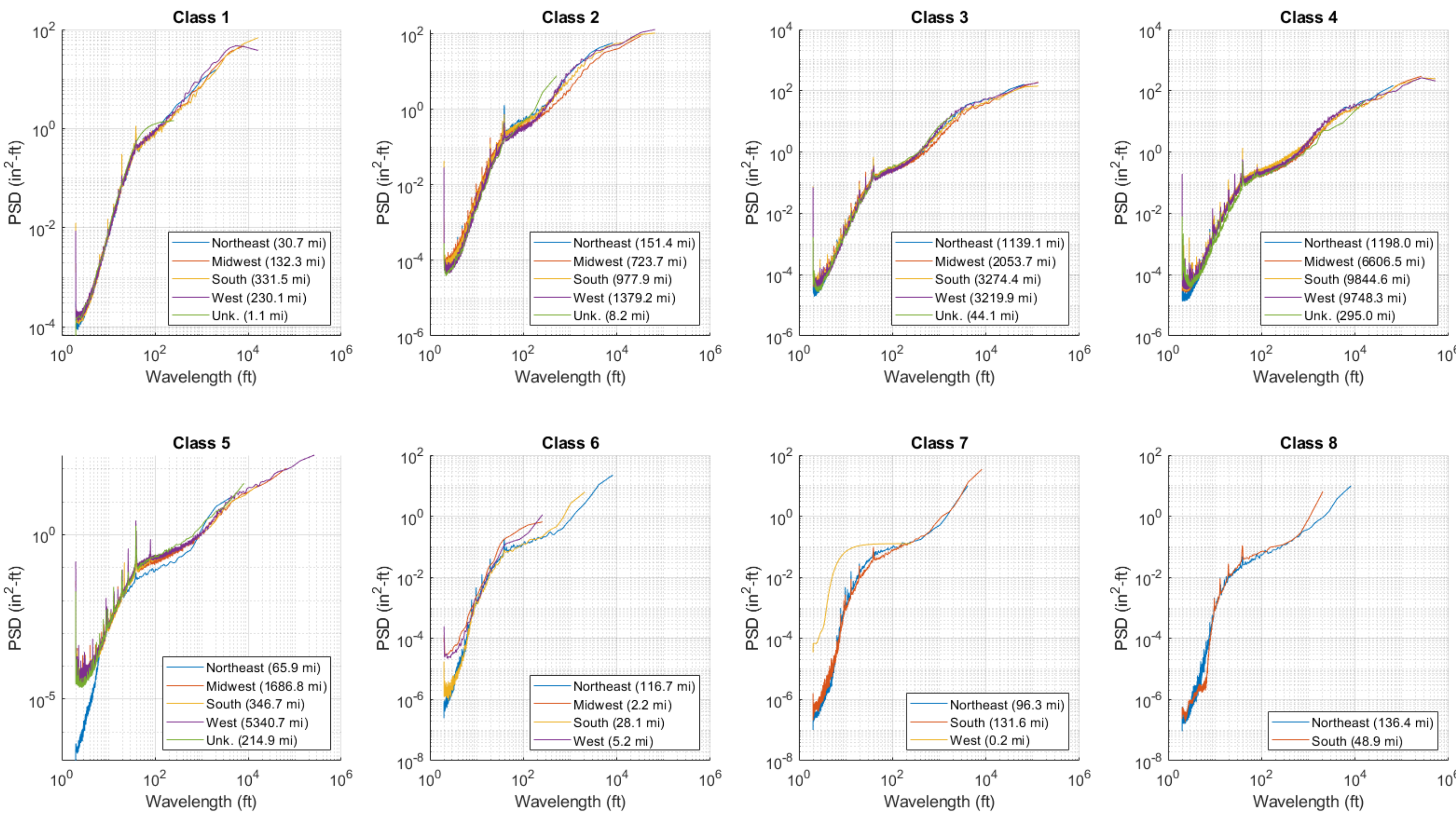

Figure 3. PSD plot of gage by geographical region

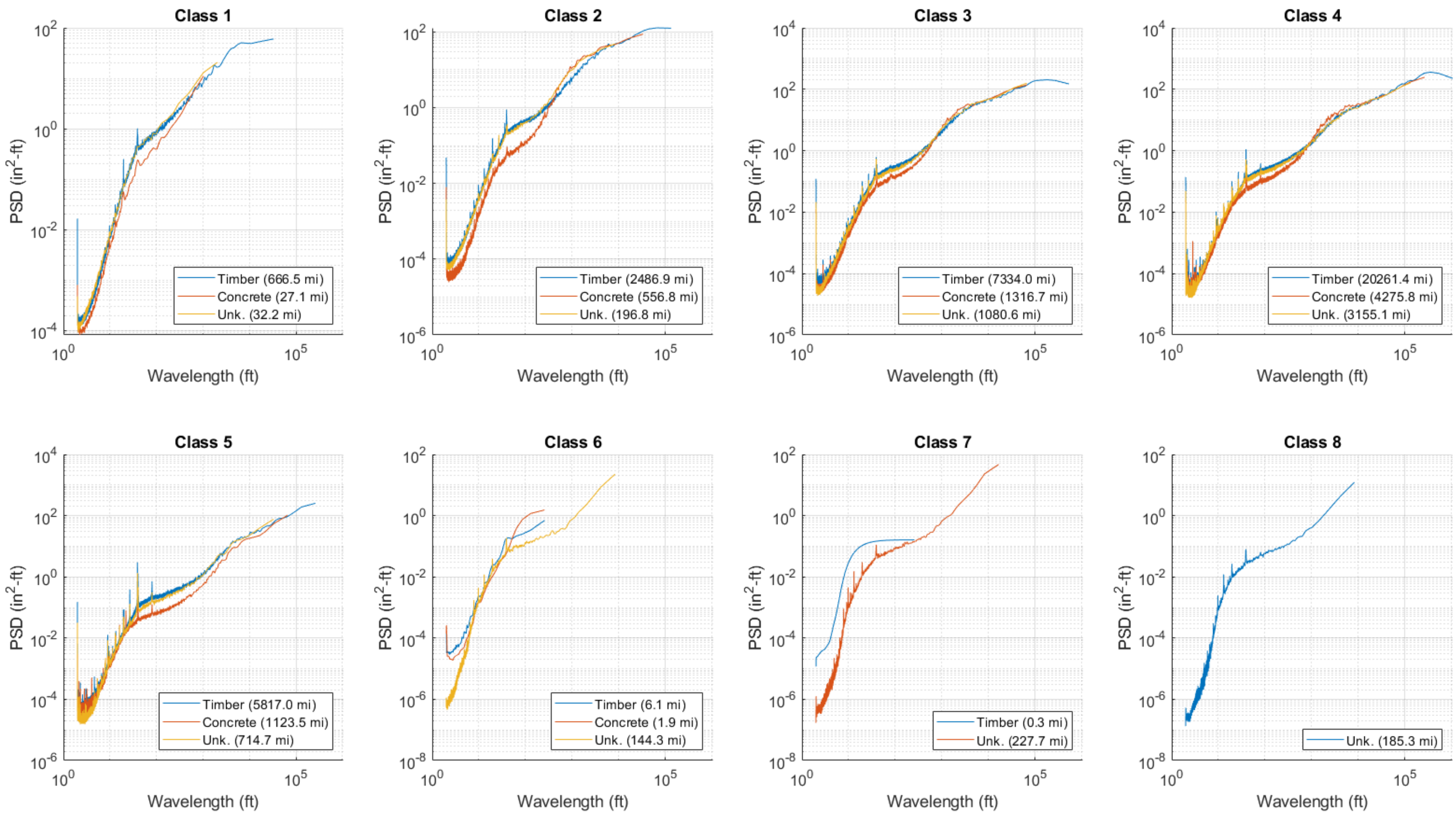

Figure 4. PSD plot of gage by tie type

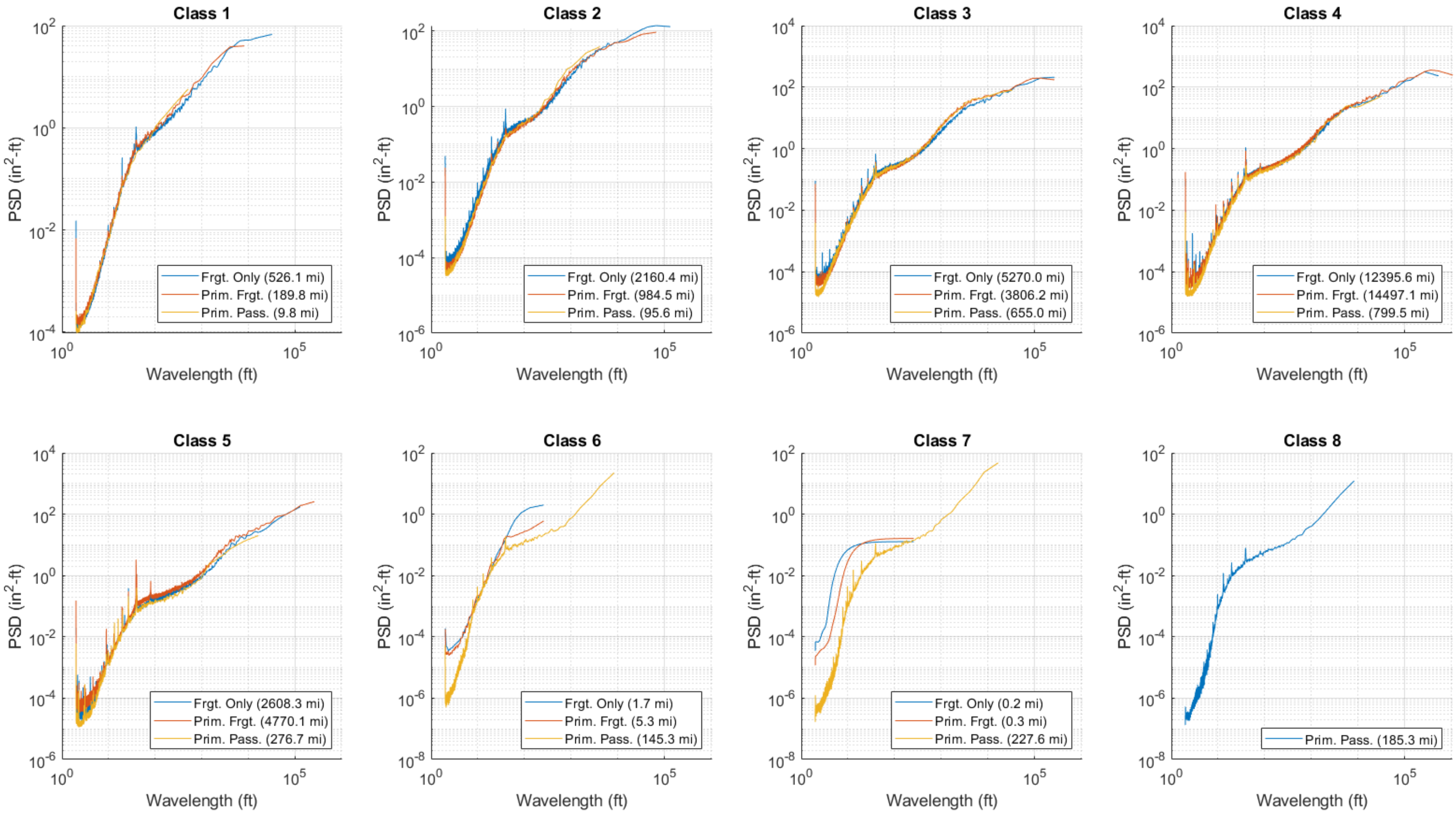

Figure 5. PSD plot of gage by traffic type

Cross level

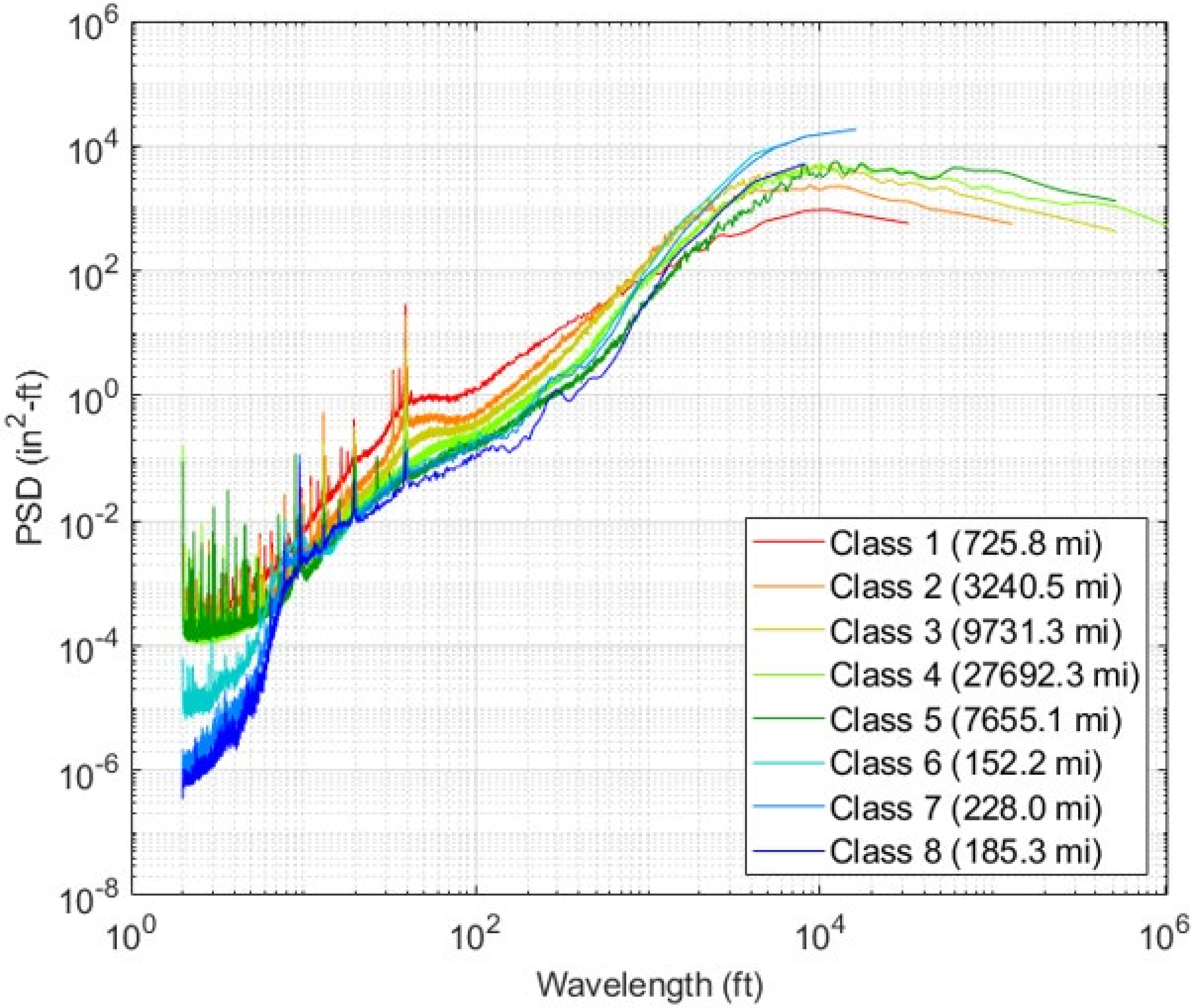

Figure 6. PSD plot of cross level by FRA track class

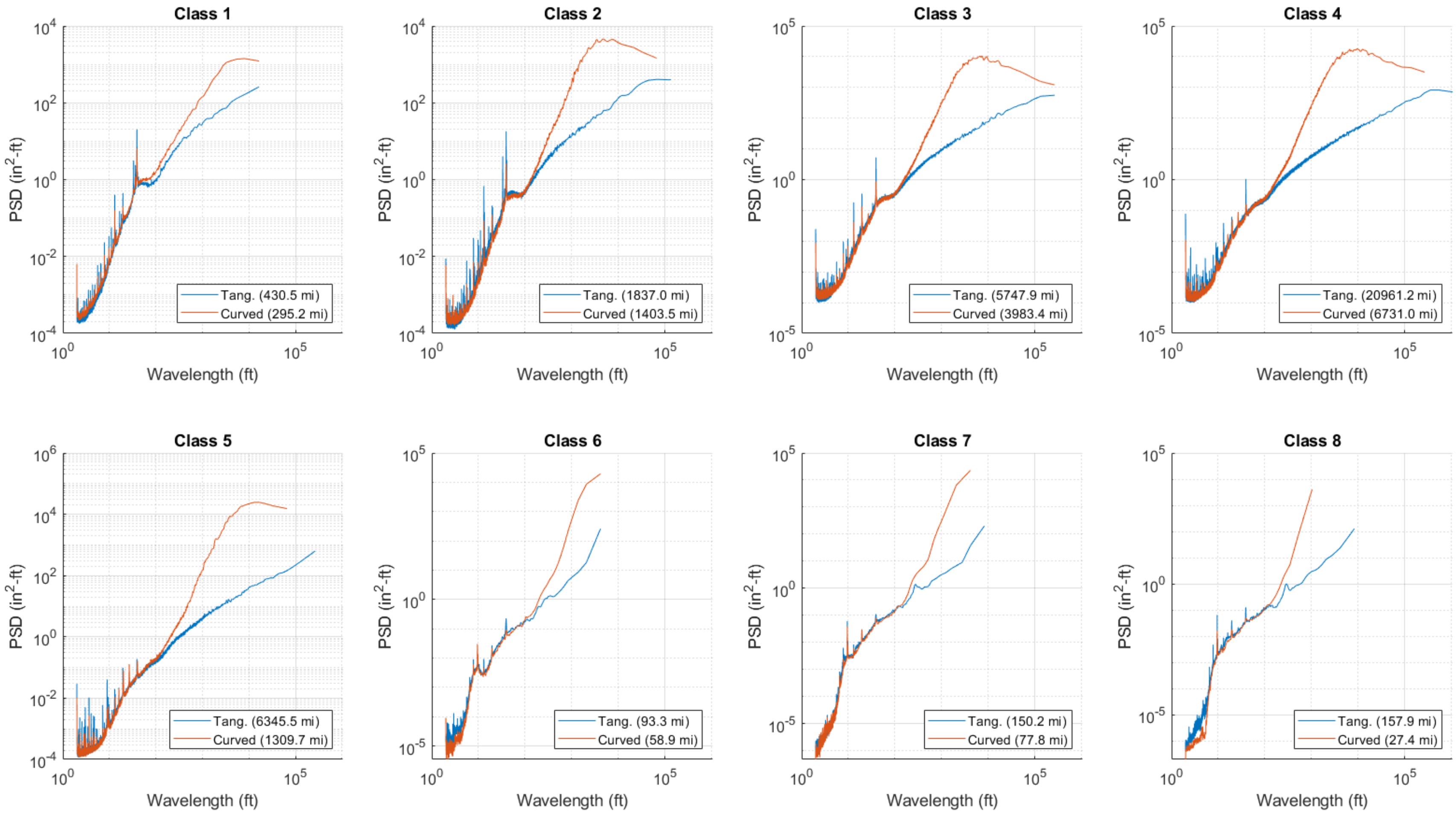

Figure 7. PSD plot of cross level by track curvature

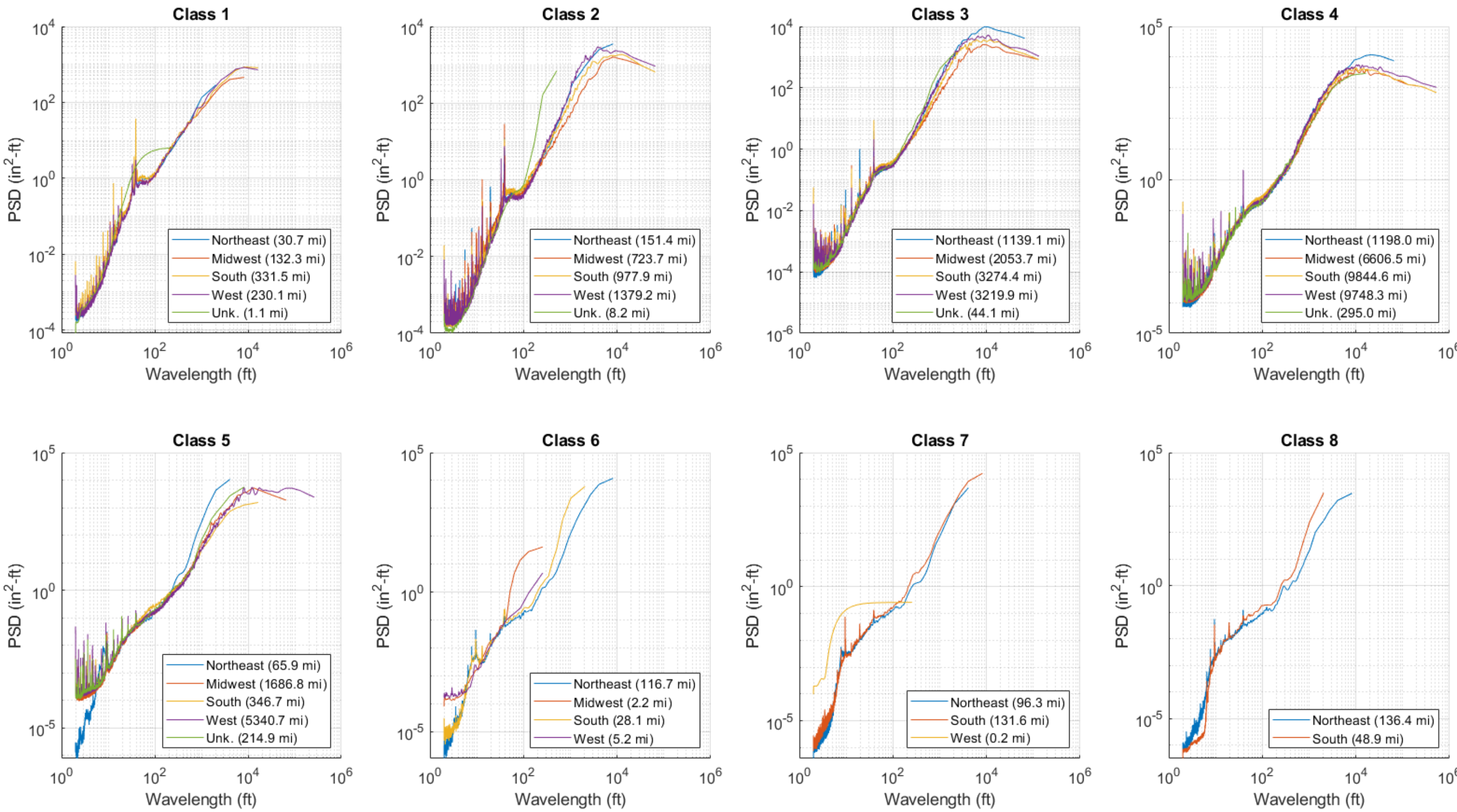

Figure 8. PSD plot of cross level by geographical region

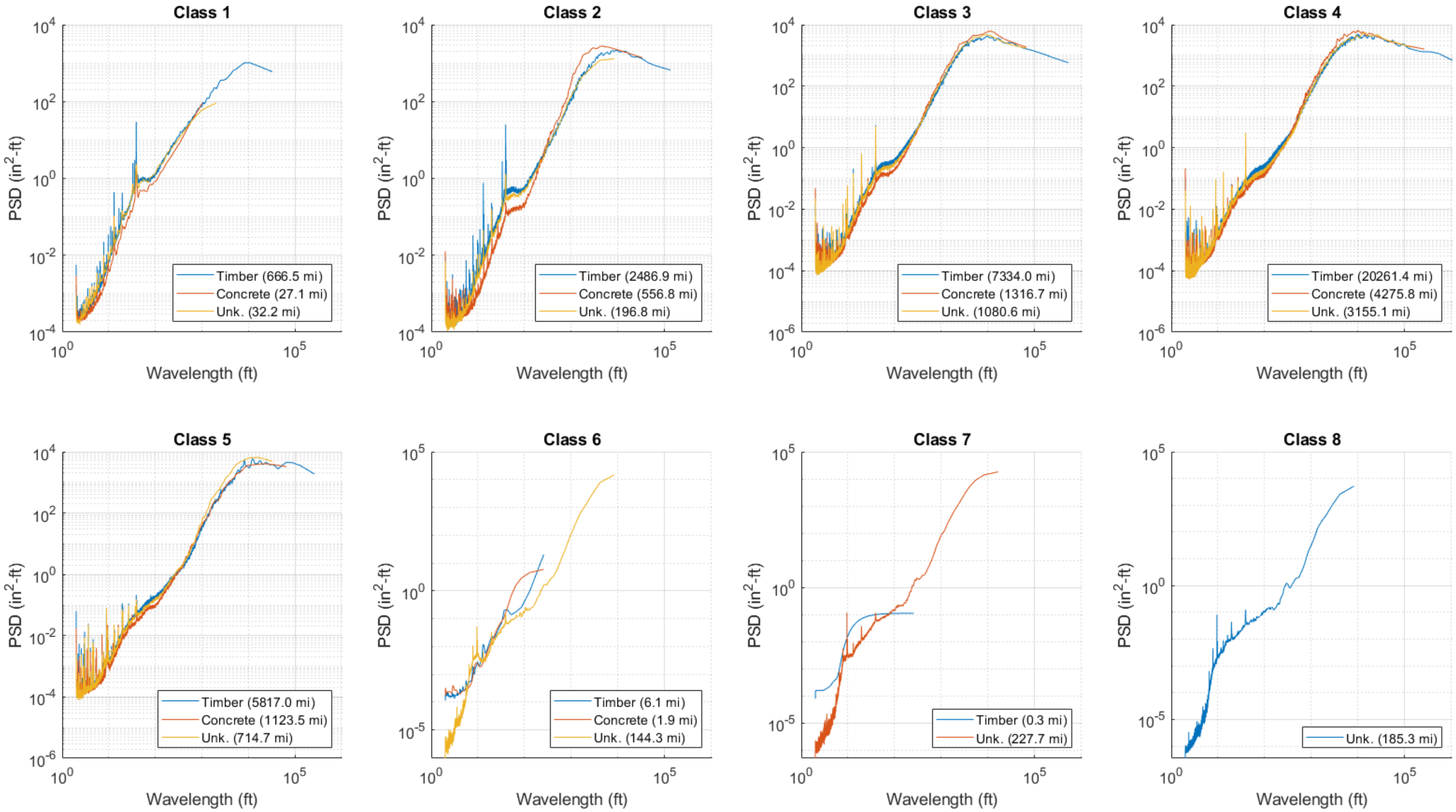

Figure 9. PSD plot of cross level by tie type

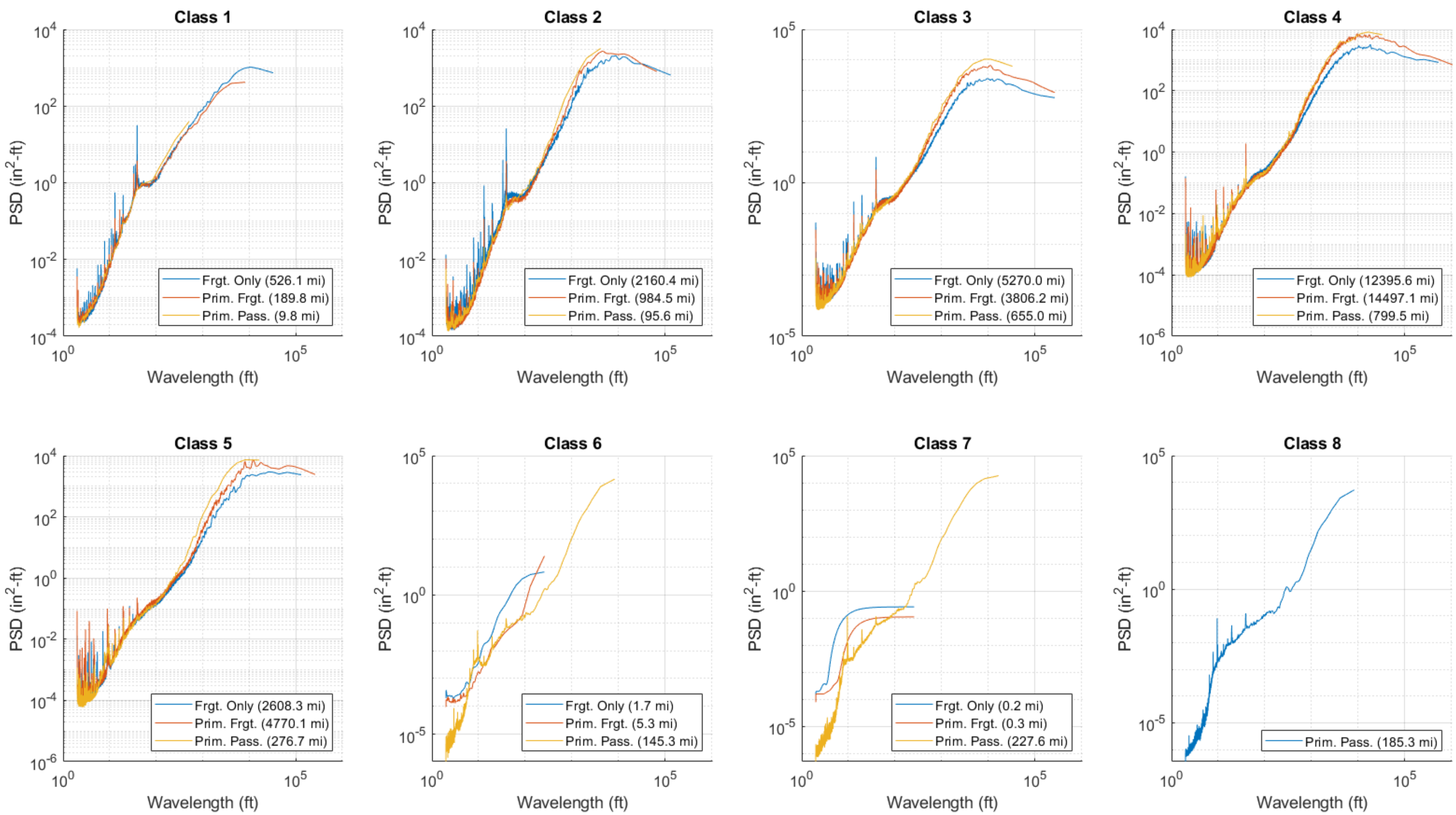

Figure 10. PSD plot of cross level by traffic type

Mean Alignment

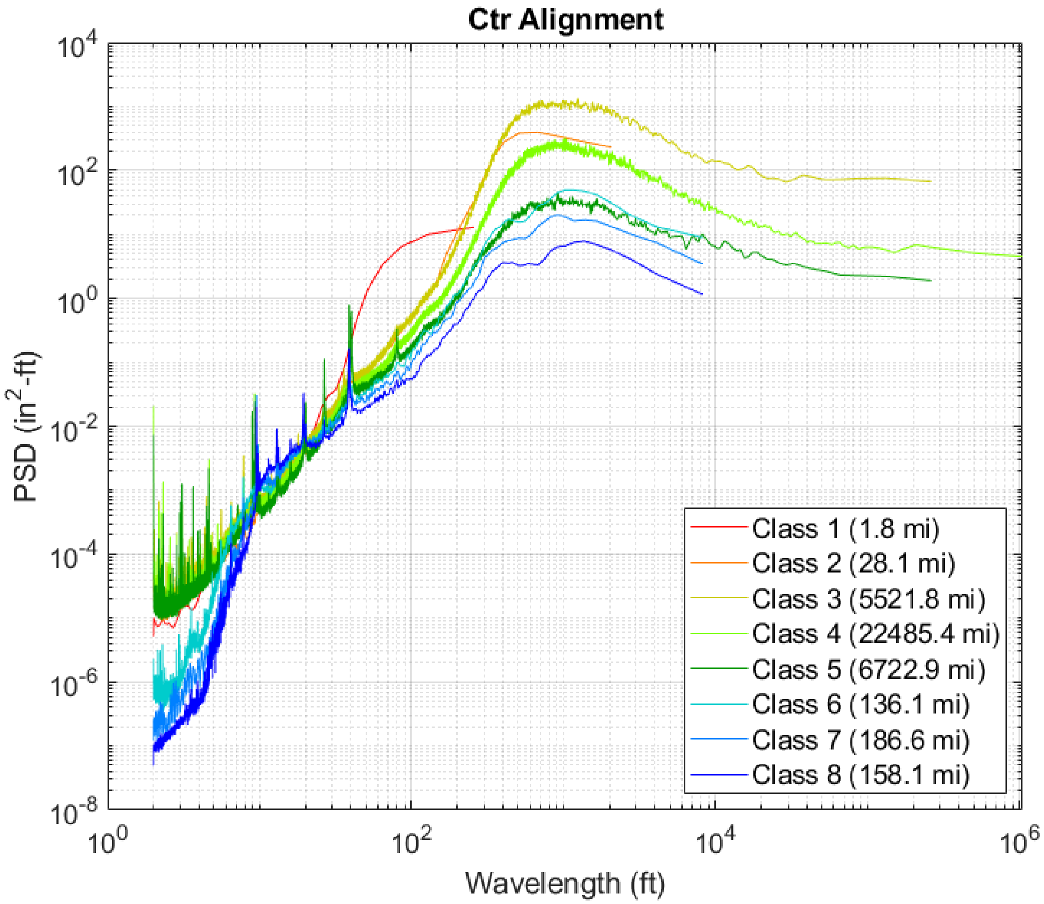

Figure 11. PSD plot of mean alignment by FRA track class

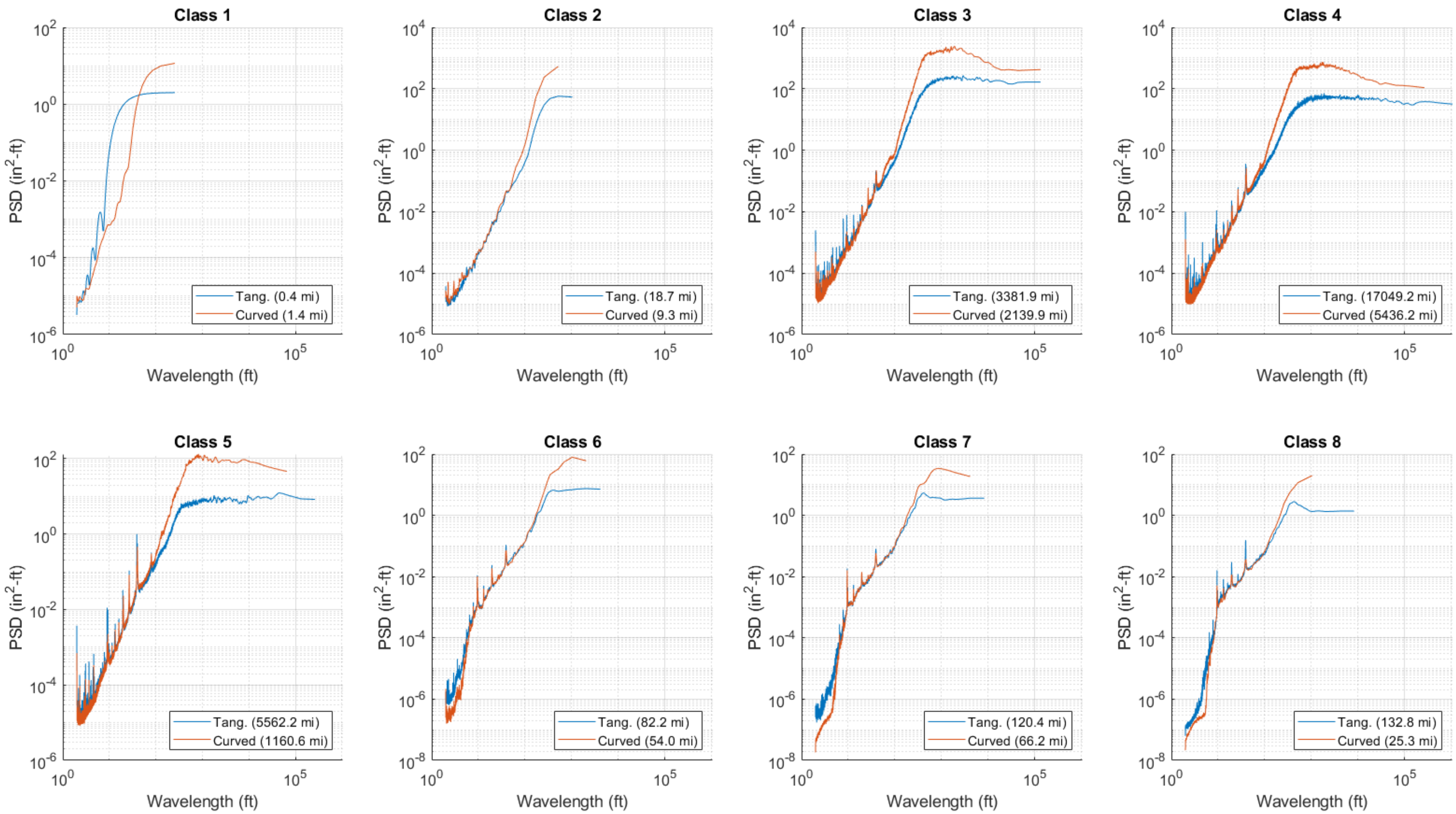

Figure 12. PSD plot of mean alignment by track curvature

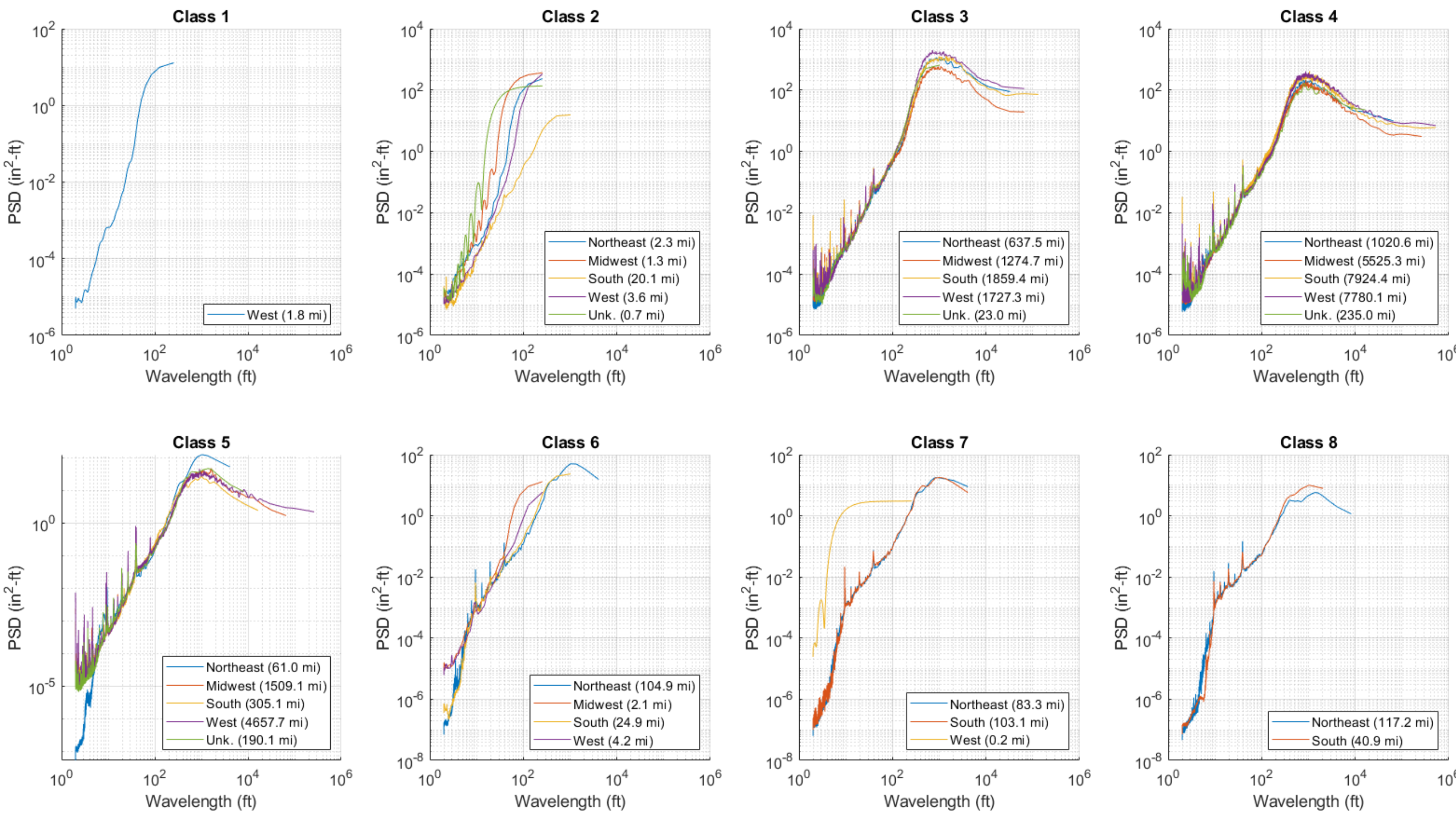

Figure 13. PSD plot of mean alignment by geographical region

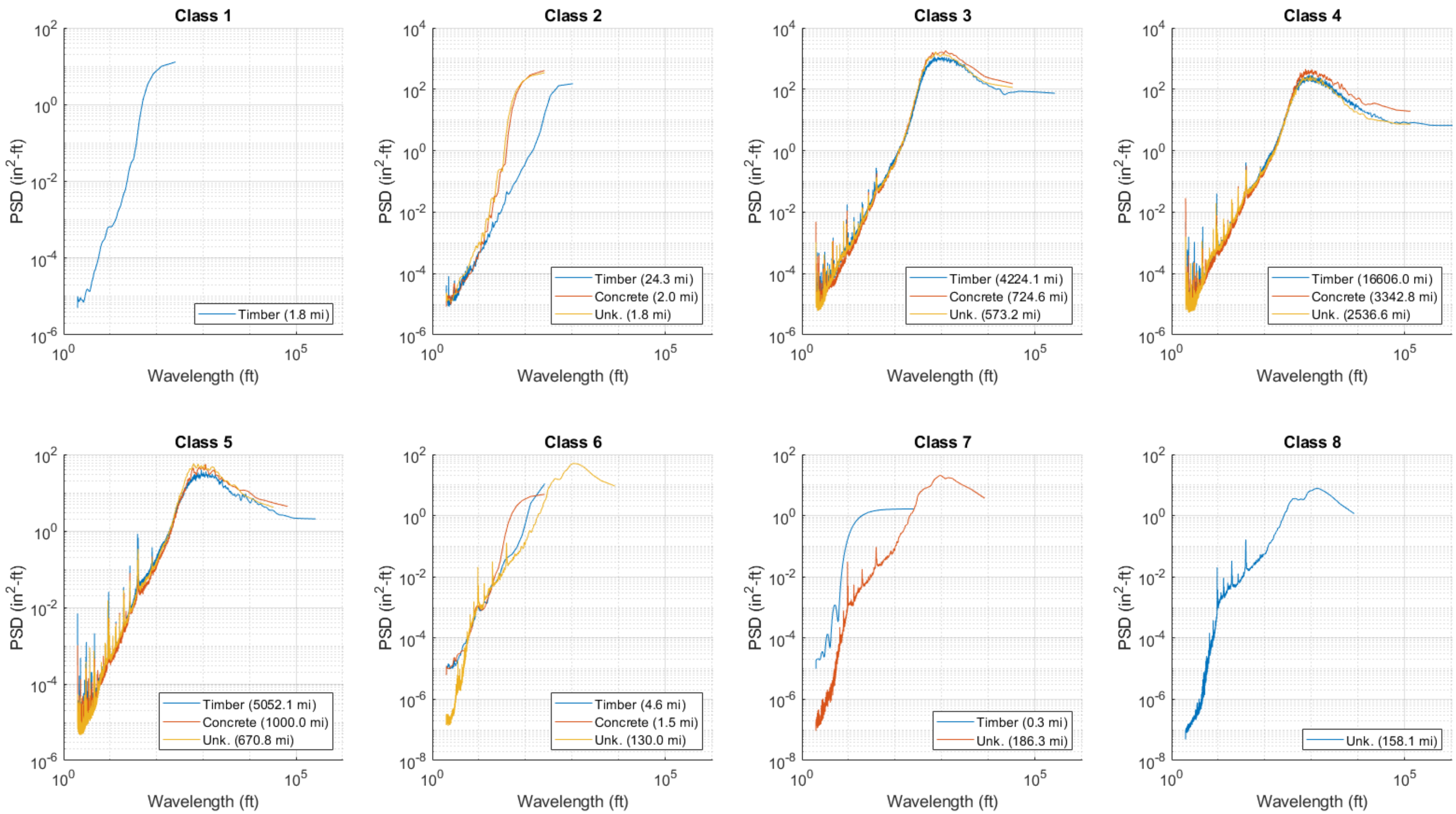

Figure 14. PSD plot of mean alignment by tie type

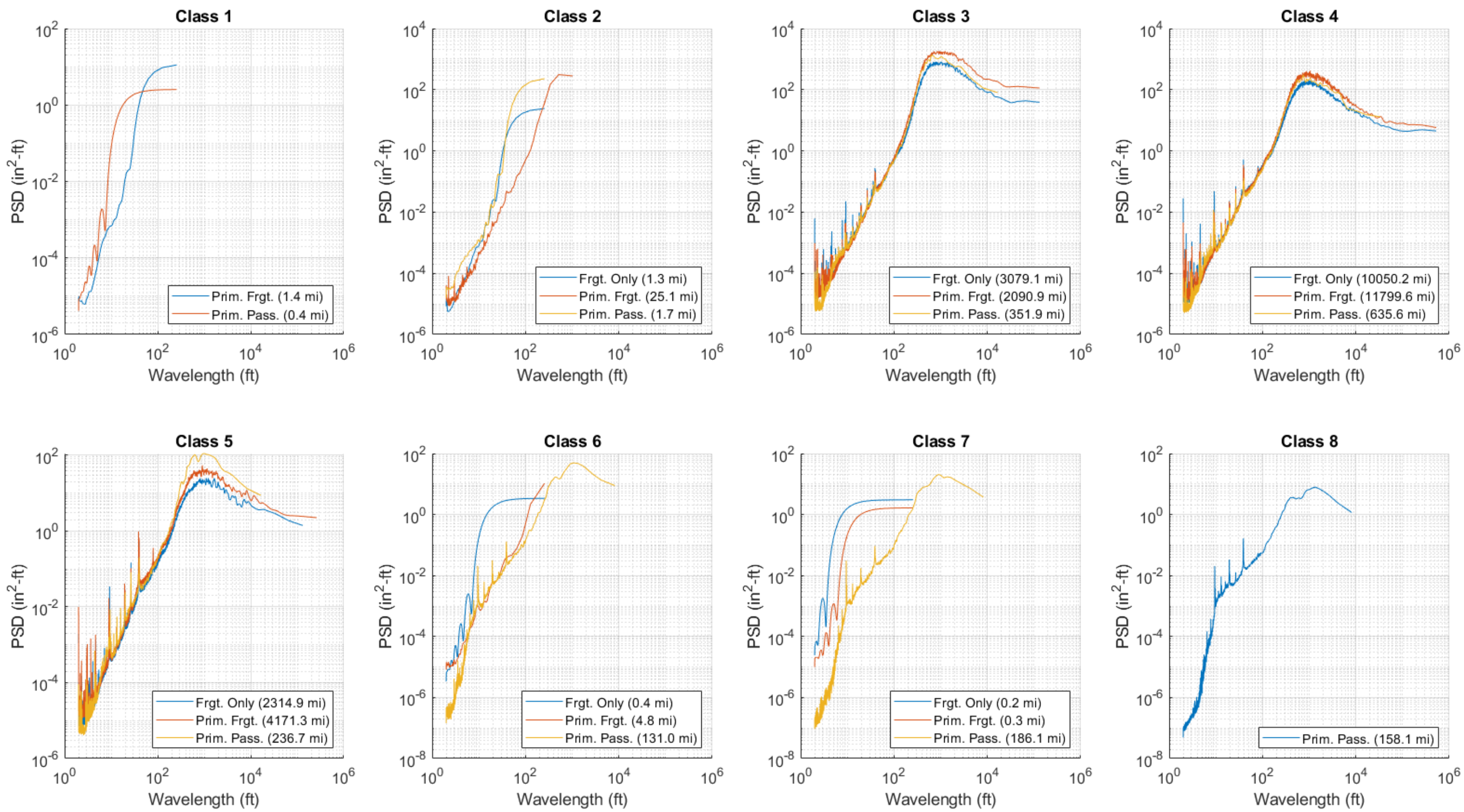

Figure 15. PSD plot of mean alignment by traffic type

Mean Surface

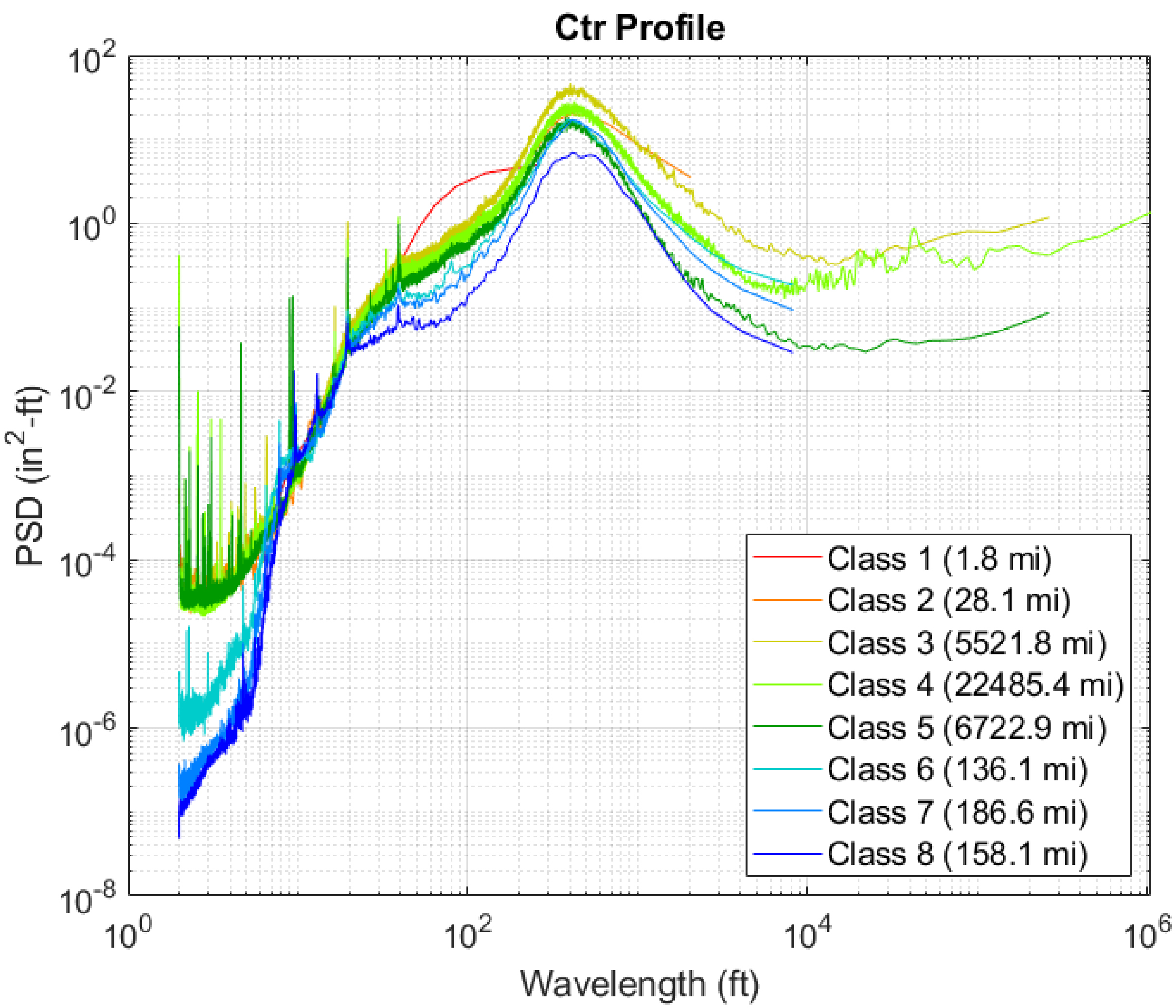

Figure 16. PSD plot of mean surface by FRA track class

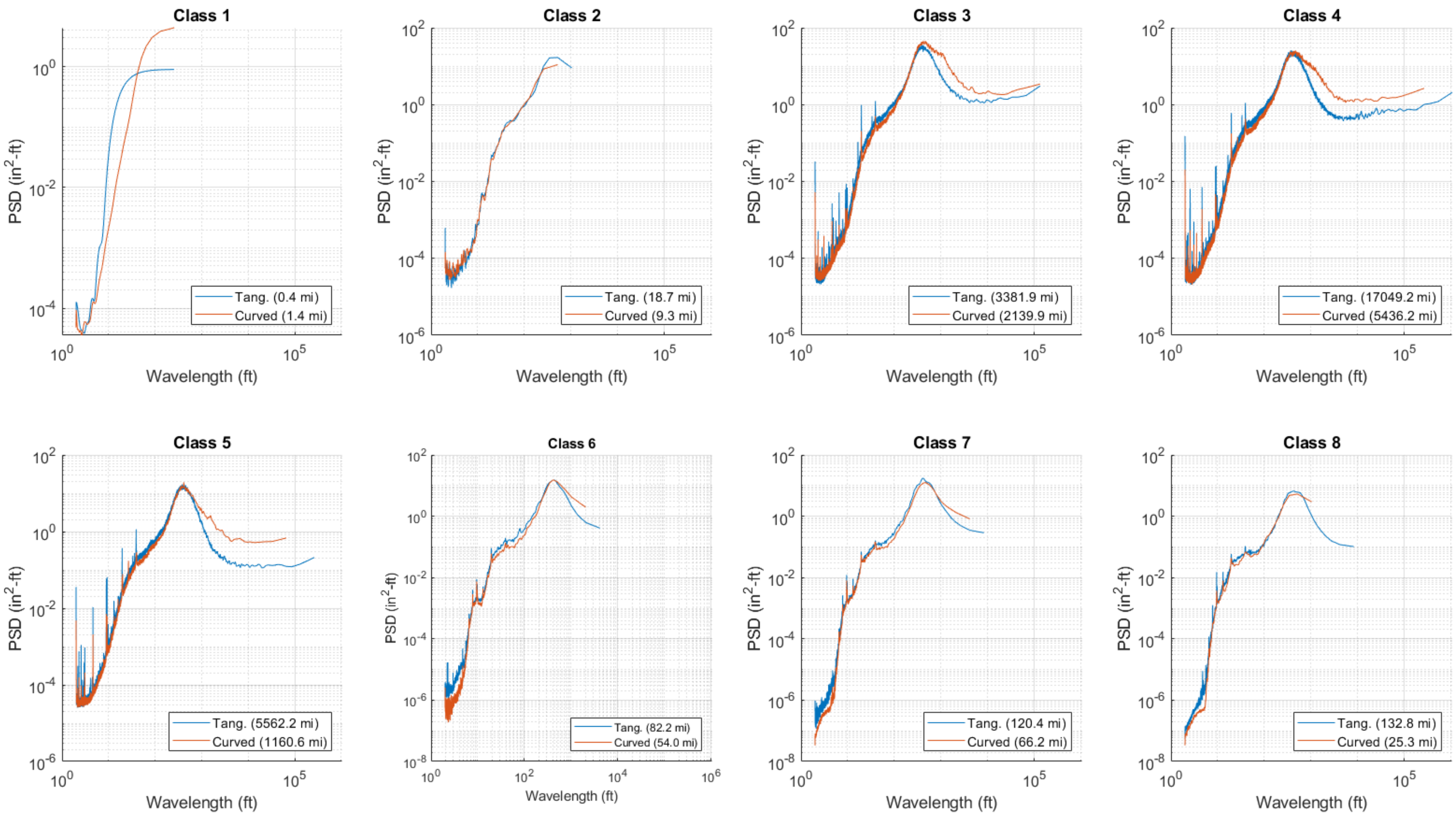

Figure 17. PSD plot of mean surface by track curvature

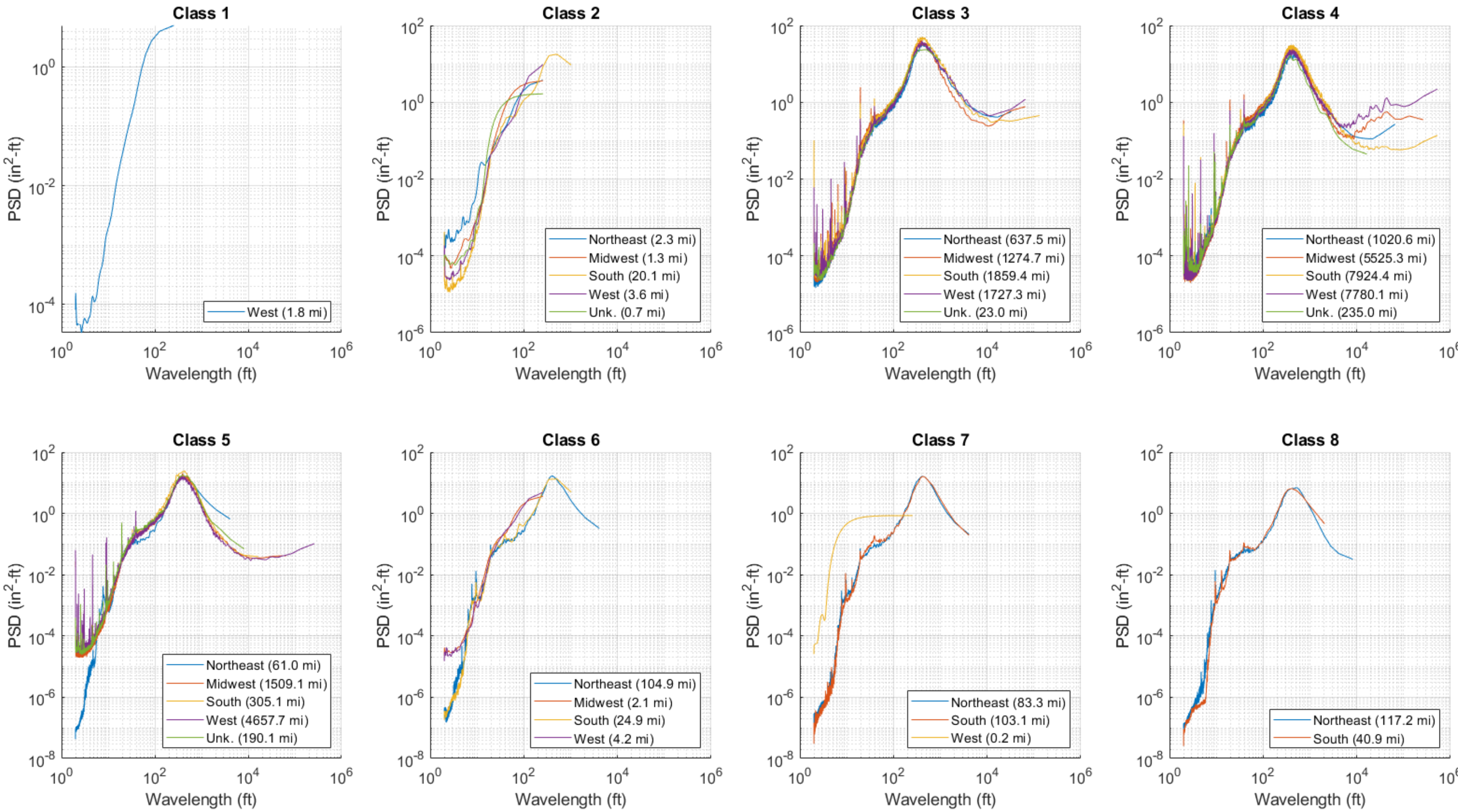

Figure 18. PSD plot of mean surface by geographical region

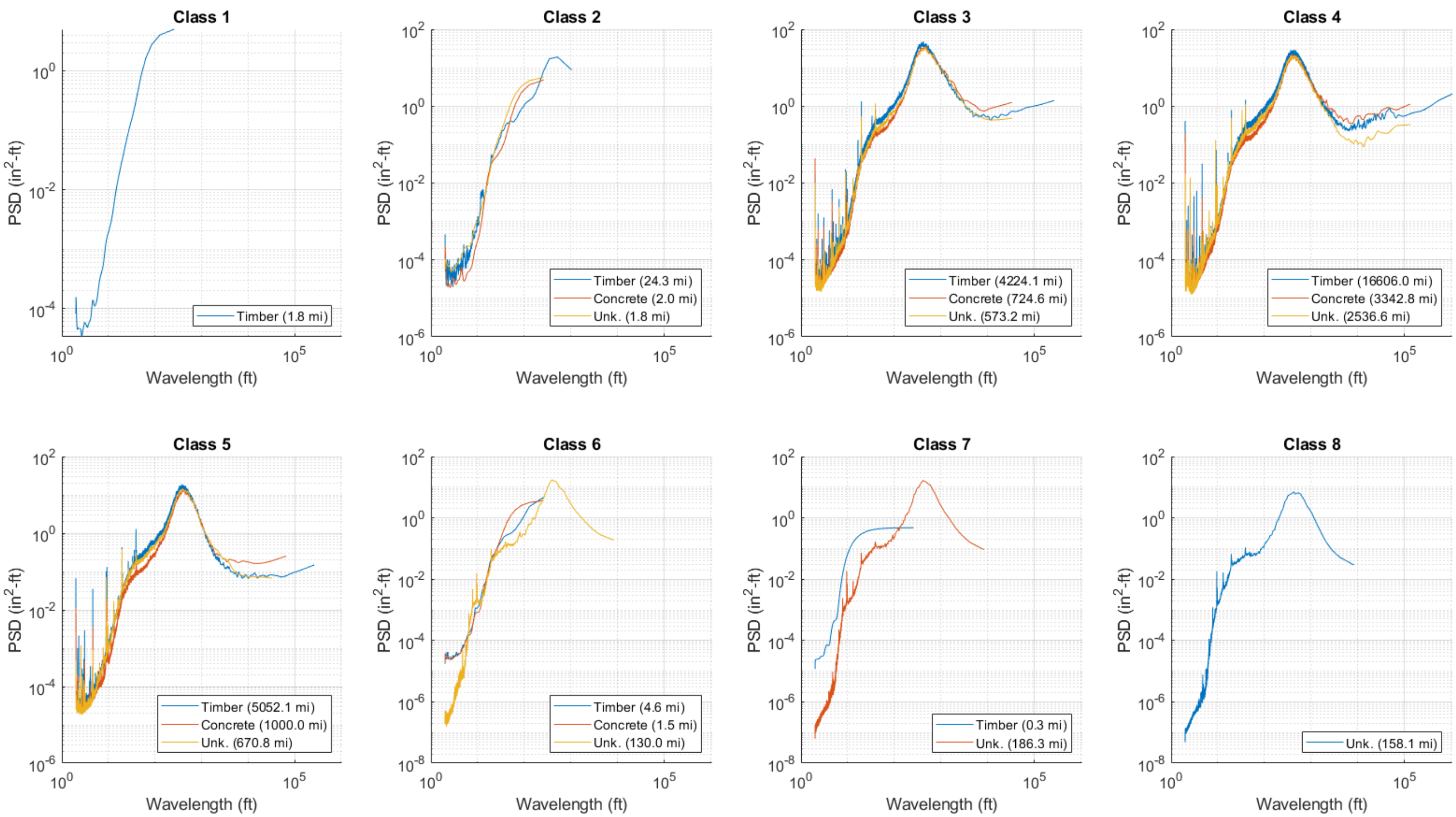

Figure 19. PSD plot of mean surface by tie type

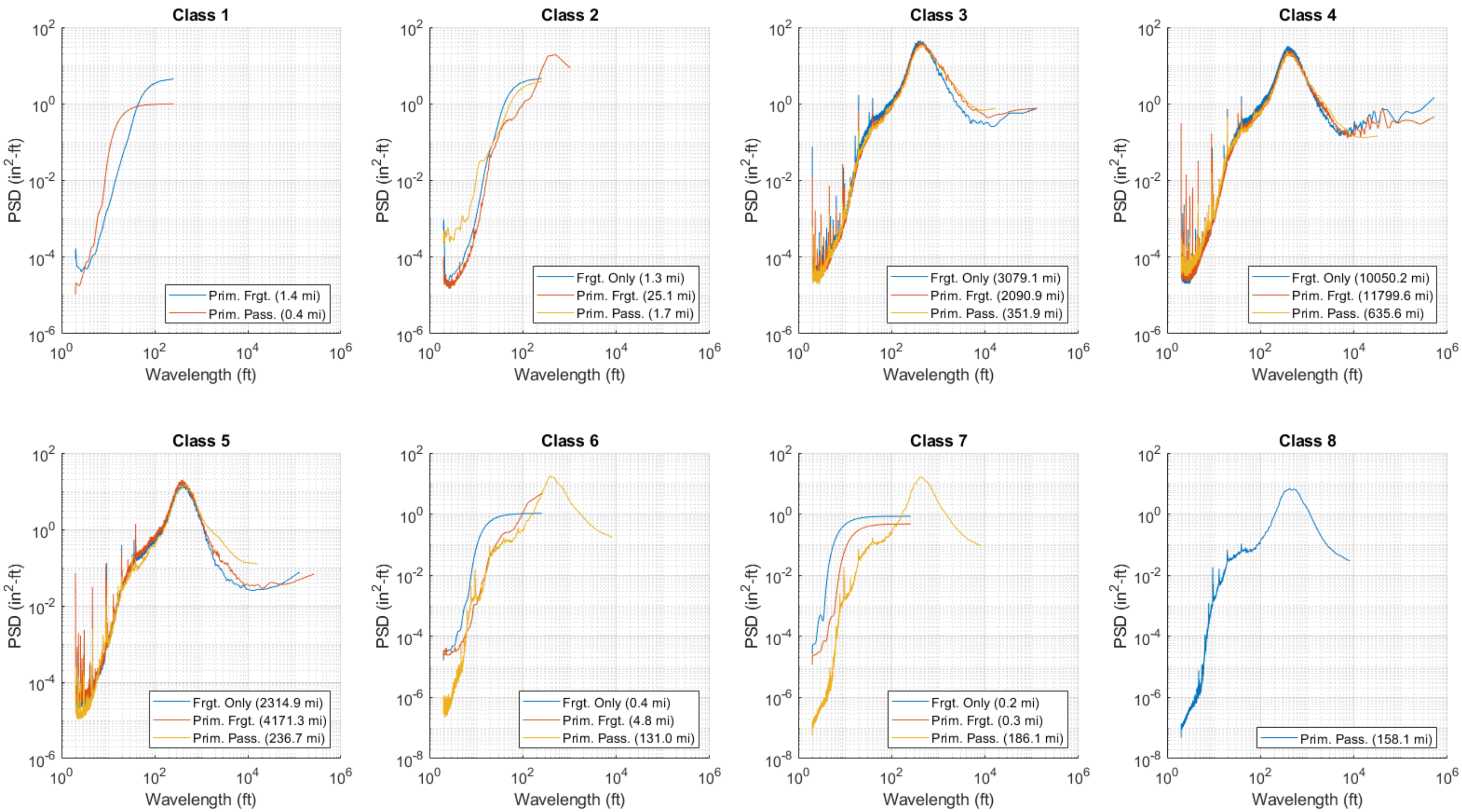

Figure 20. PSD plot of mean surface by traffic type

Left & Right Alignment

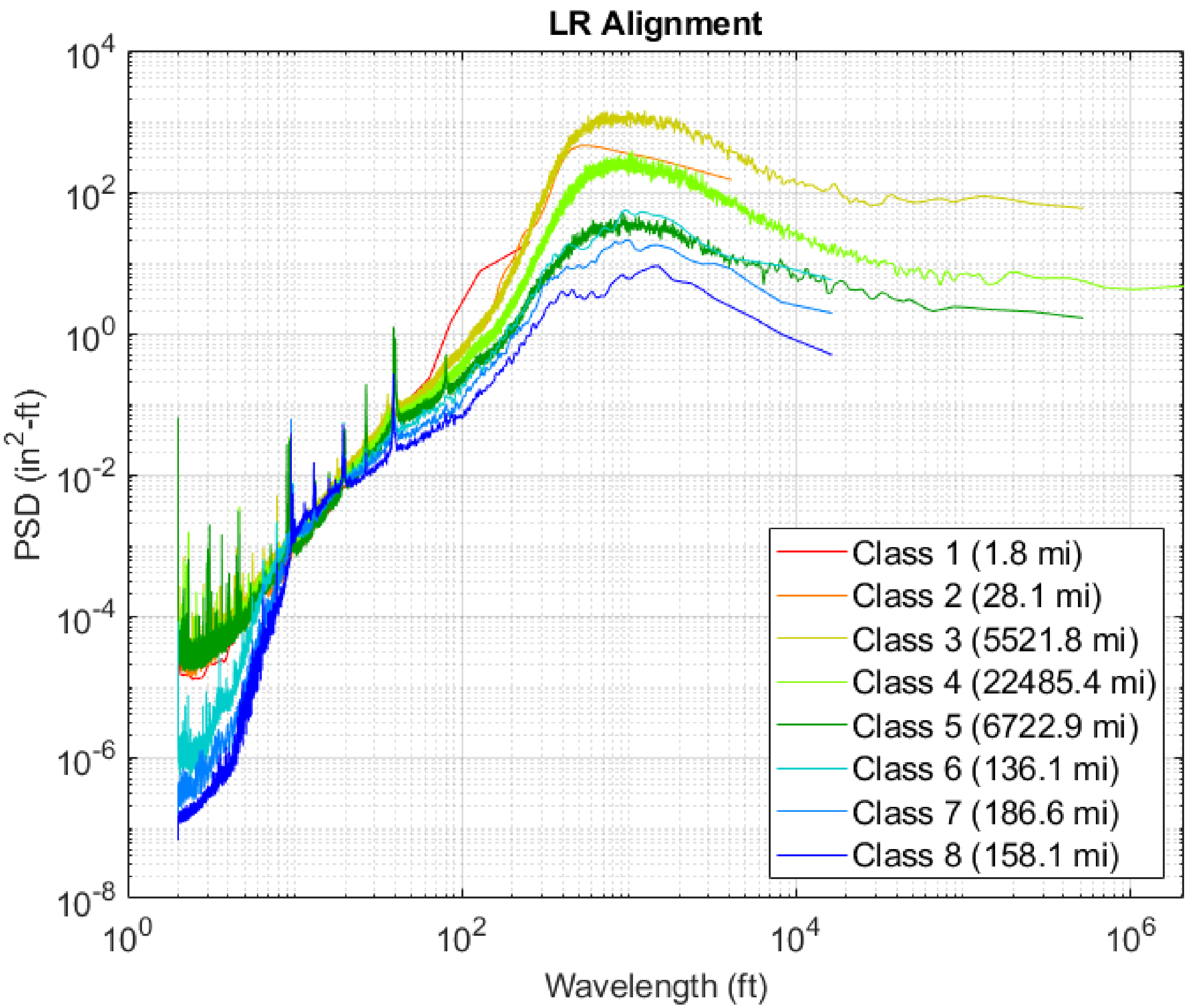

Figure 21. PSD plot of L&R alignment by FRA track class

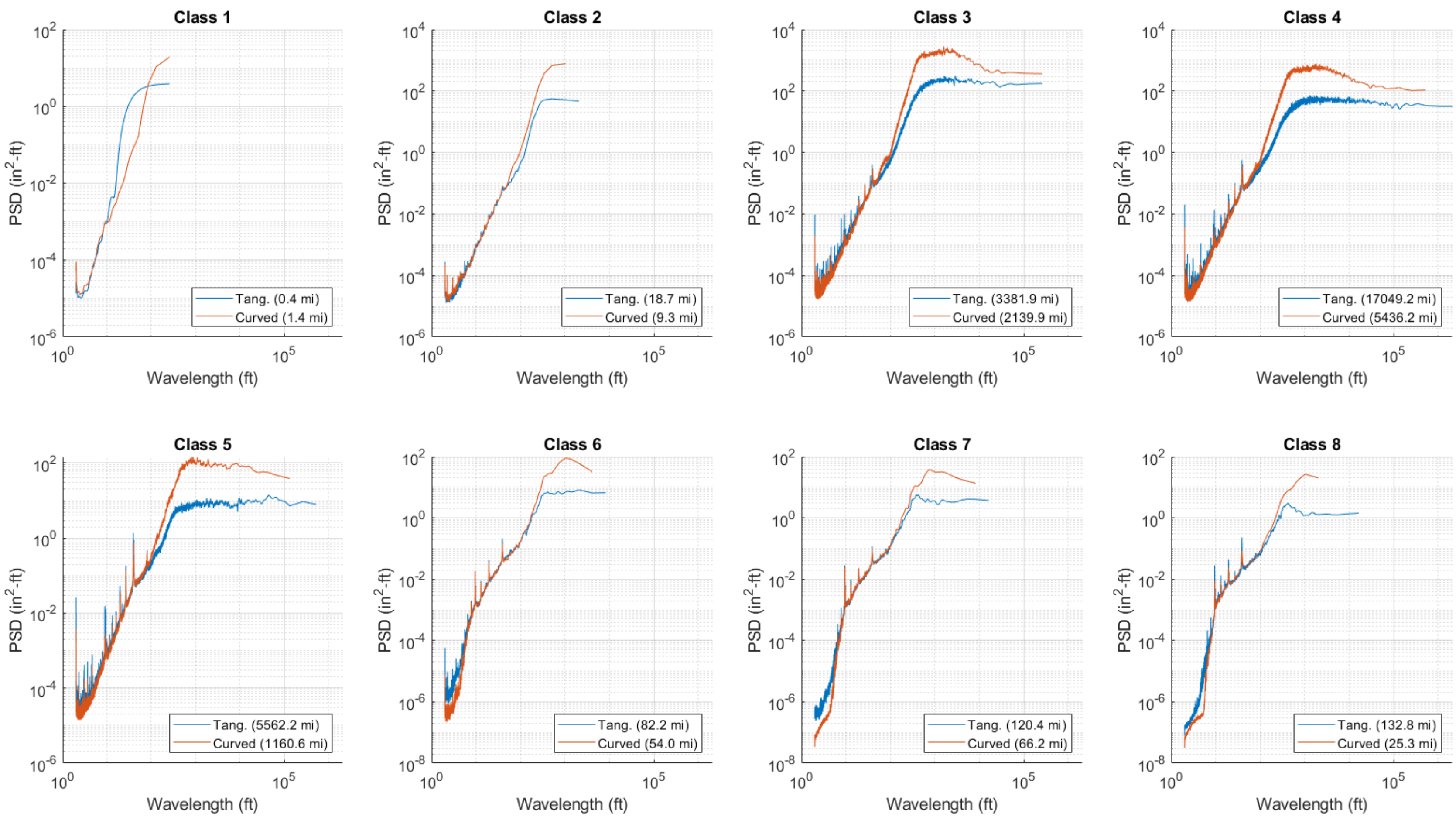

Figure 22. PSD plot of L&R alignment by track curvature

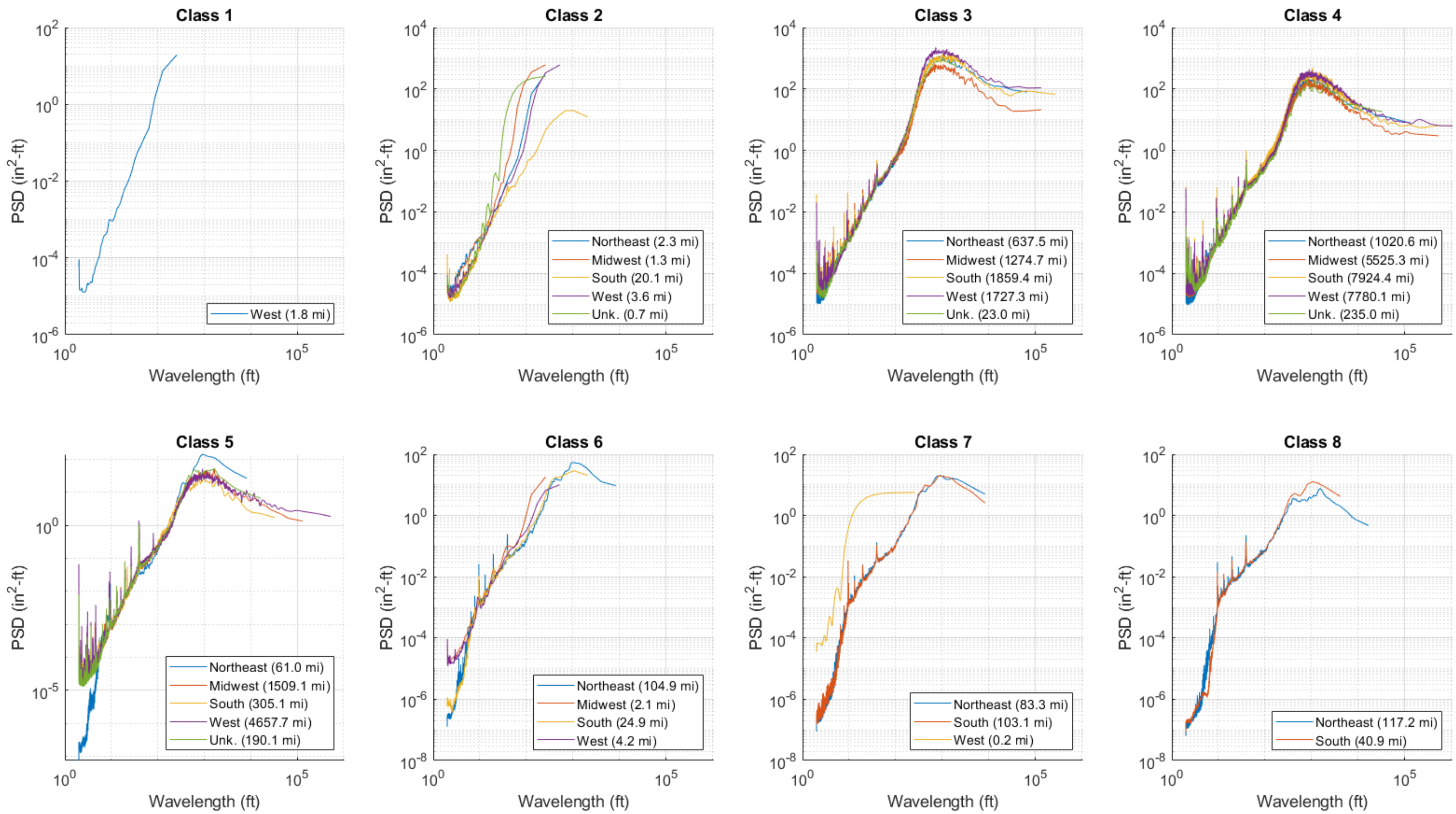

Figure 23. PSD plot of L&R alignment by geographical region

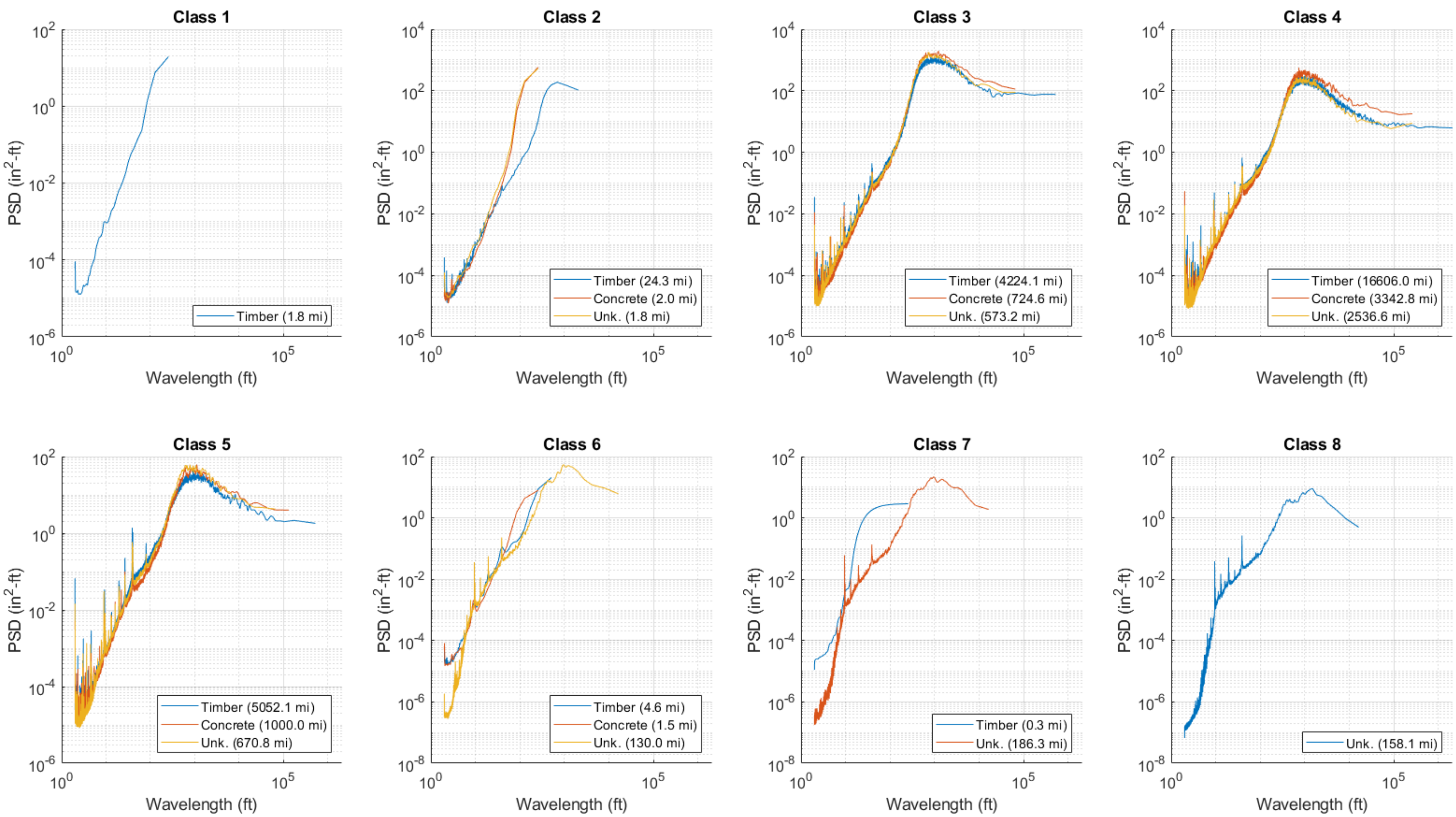

Figure 24. PSD plot of L&R alignment by tie type

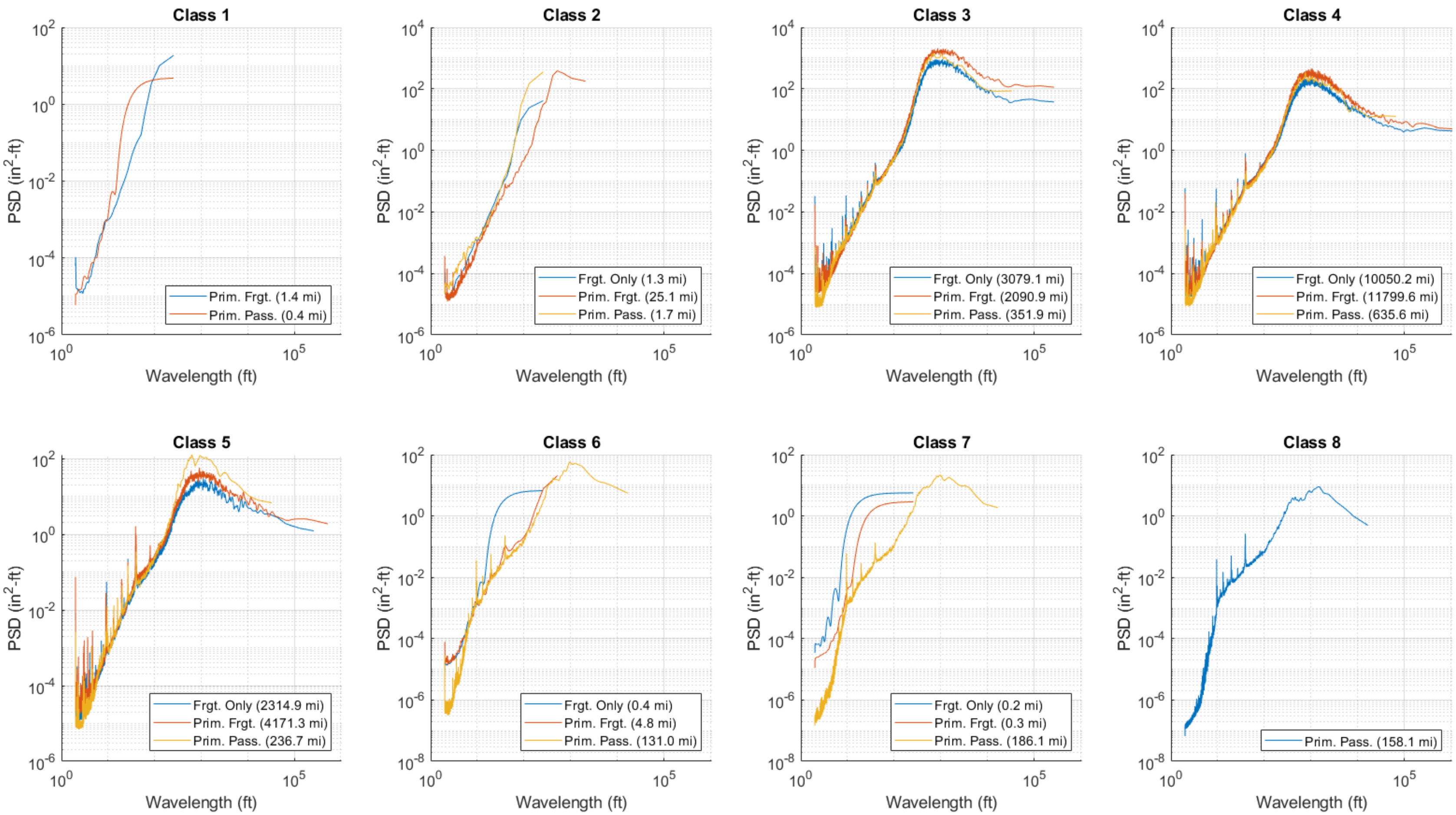

Figure 25. PSD plot of L&R alignment by traffic type

Left & Right Surface

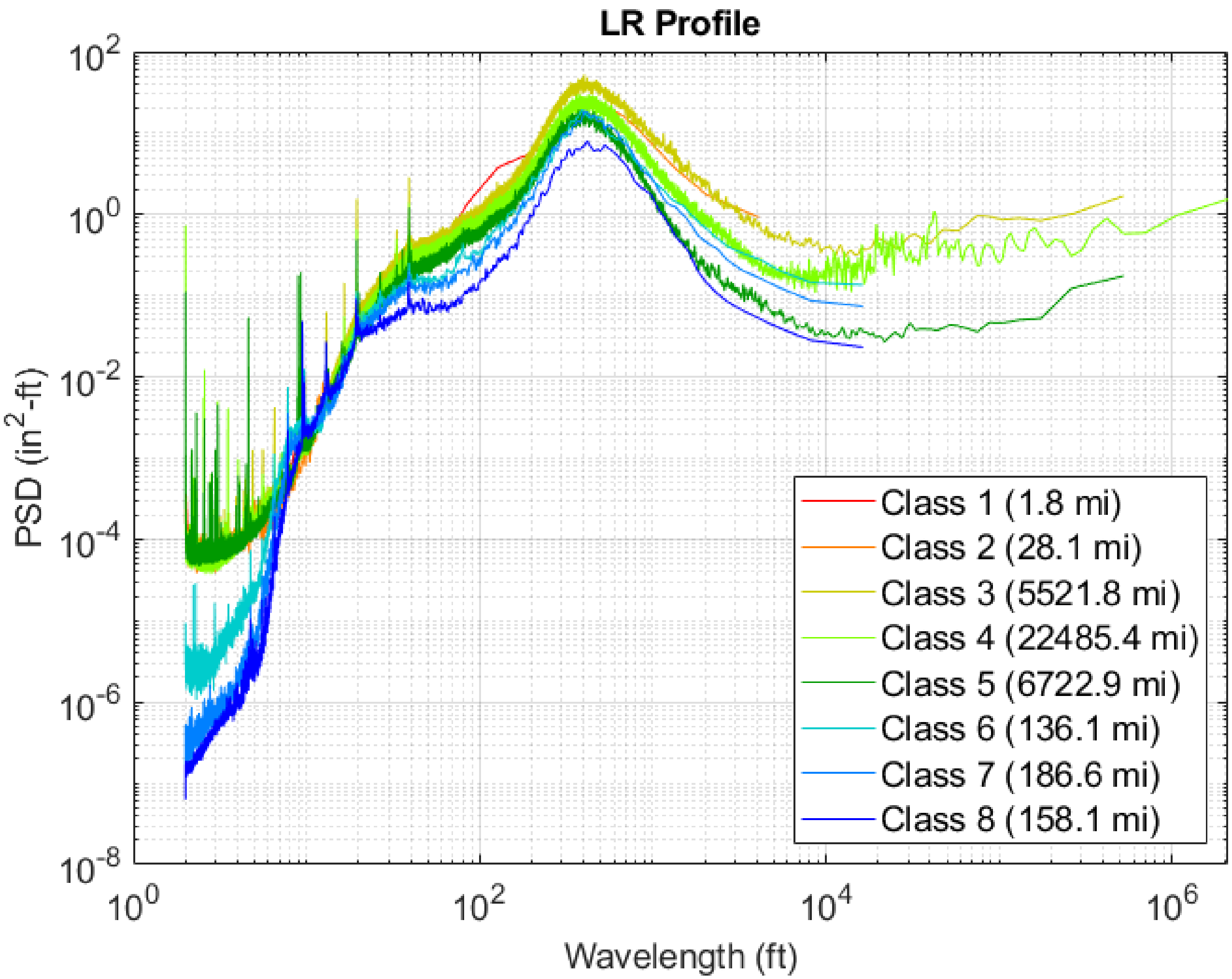

Figure 26. PSD plot of L&R surface by FRA track class

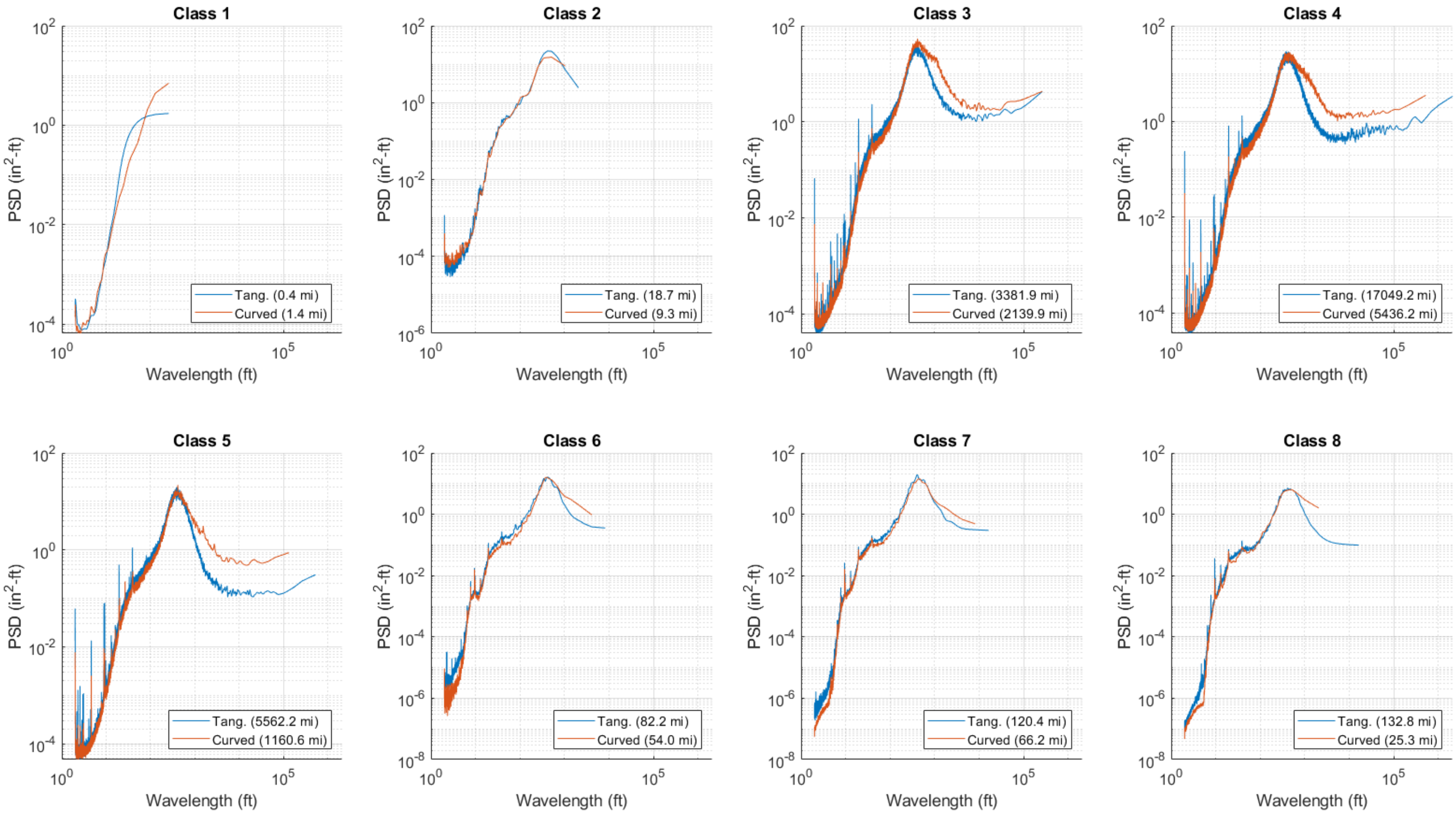

Figure 27. PSD plot of L&R surface by track curvature

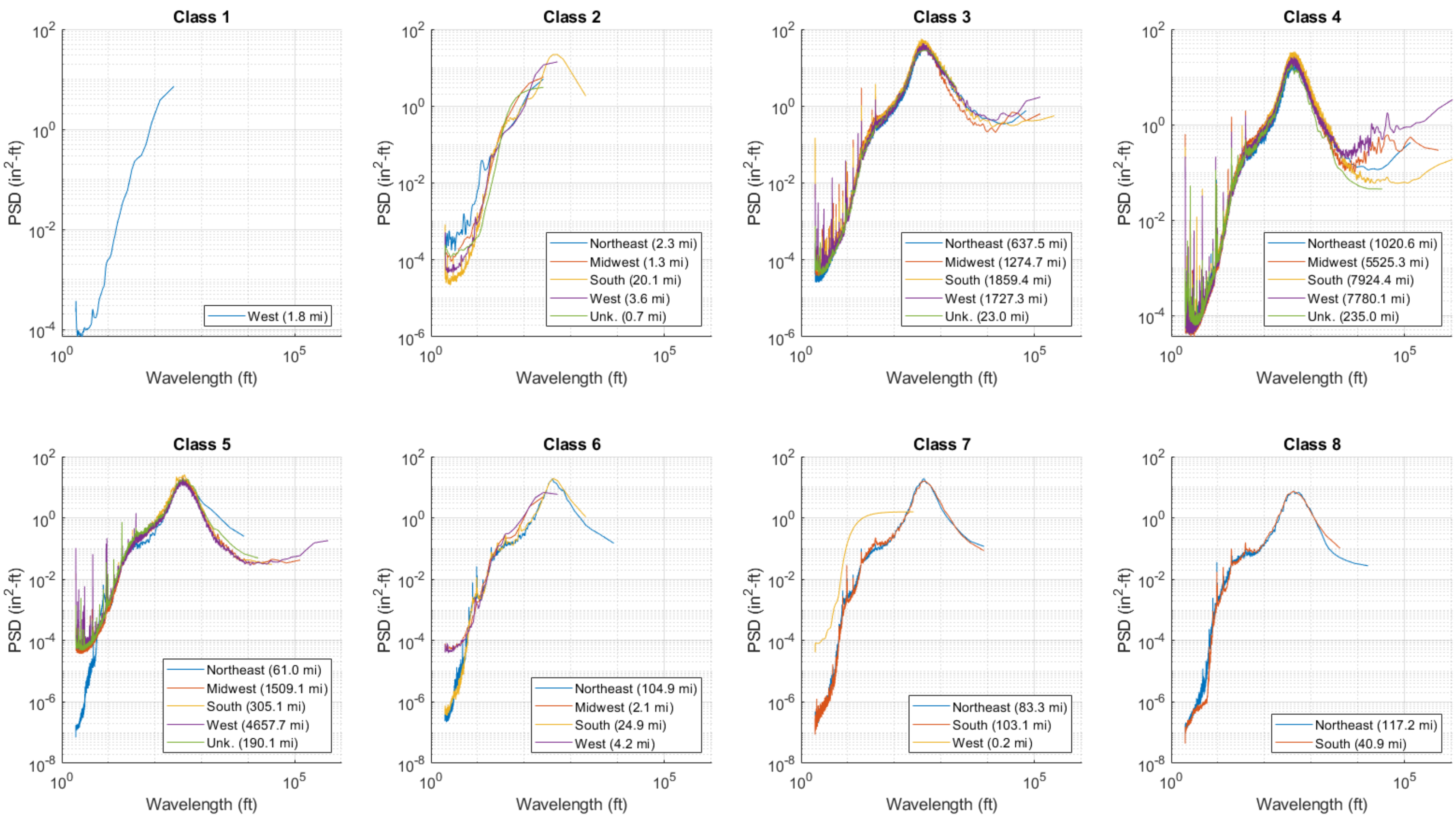

Figure 28. PSD plot of L&R surface by geographical region

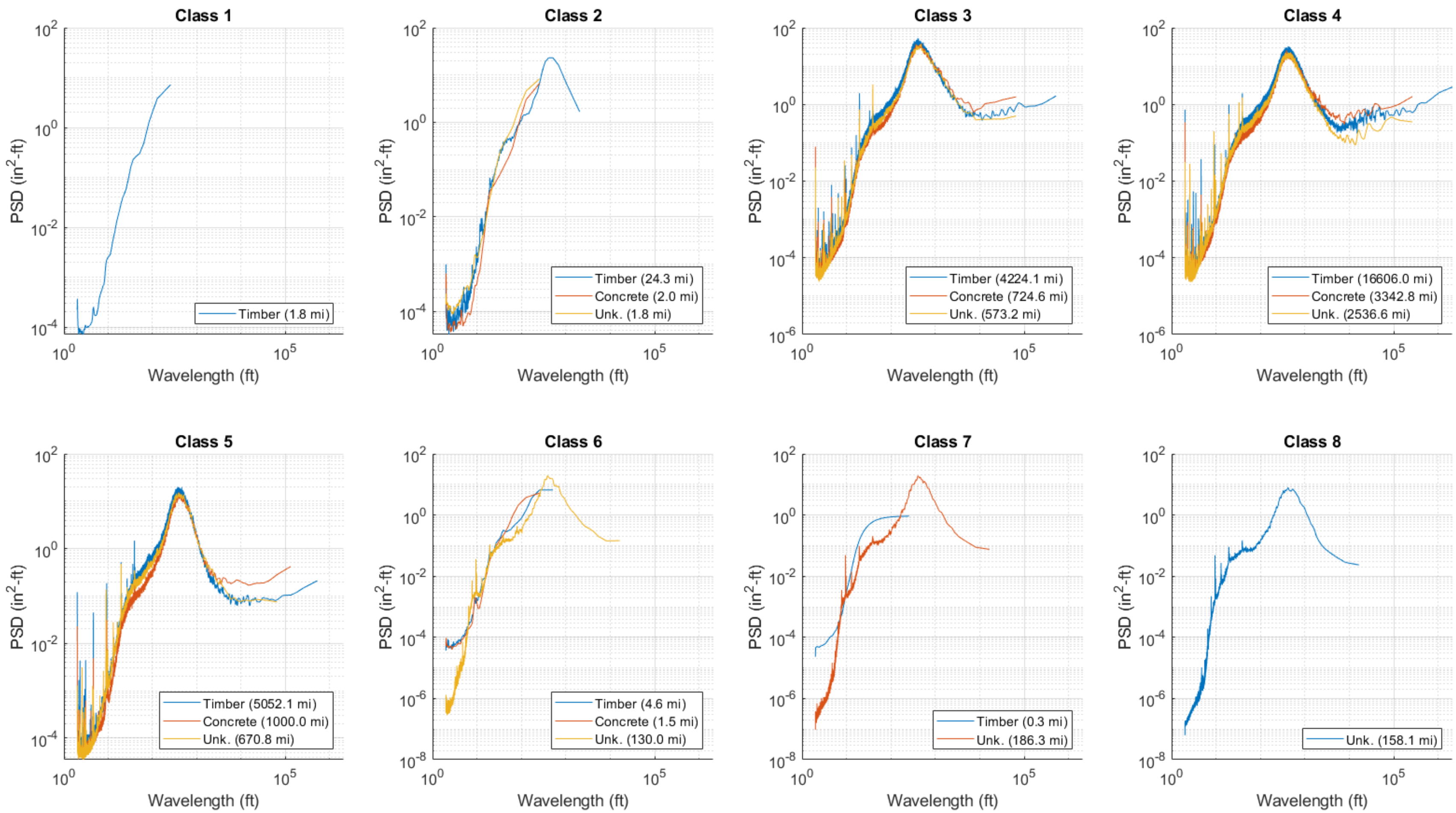

Figure 29. PSD plot of L&R surface by tie type

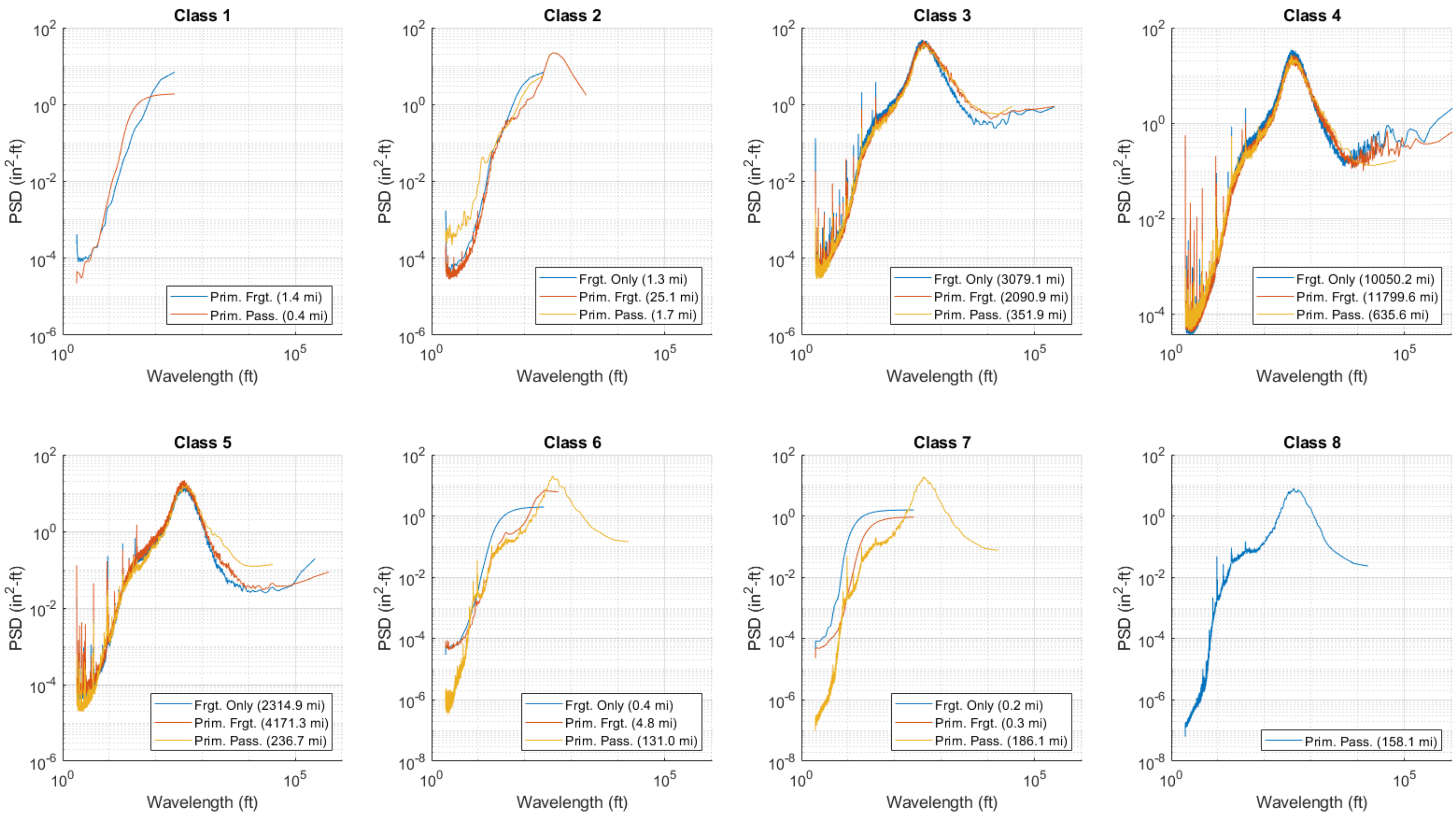

Figure 30. PSD plot of L&R surface by traffic type

Appendix D.
Clustering Plots

This appendix contains the clustering plots discussed in Section 7.2.

Gage (200-foot Filter)

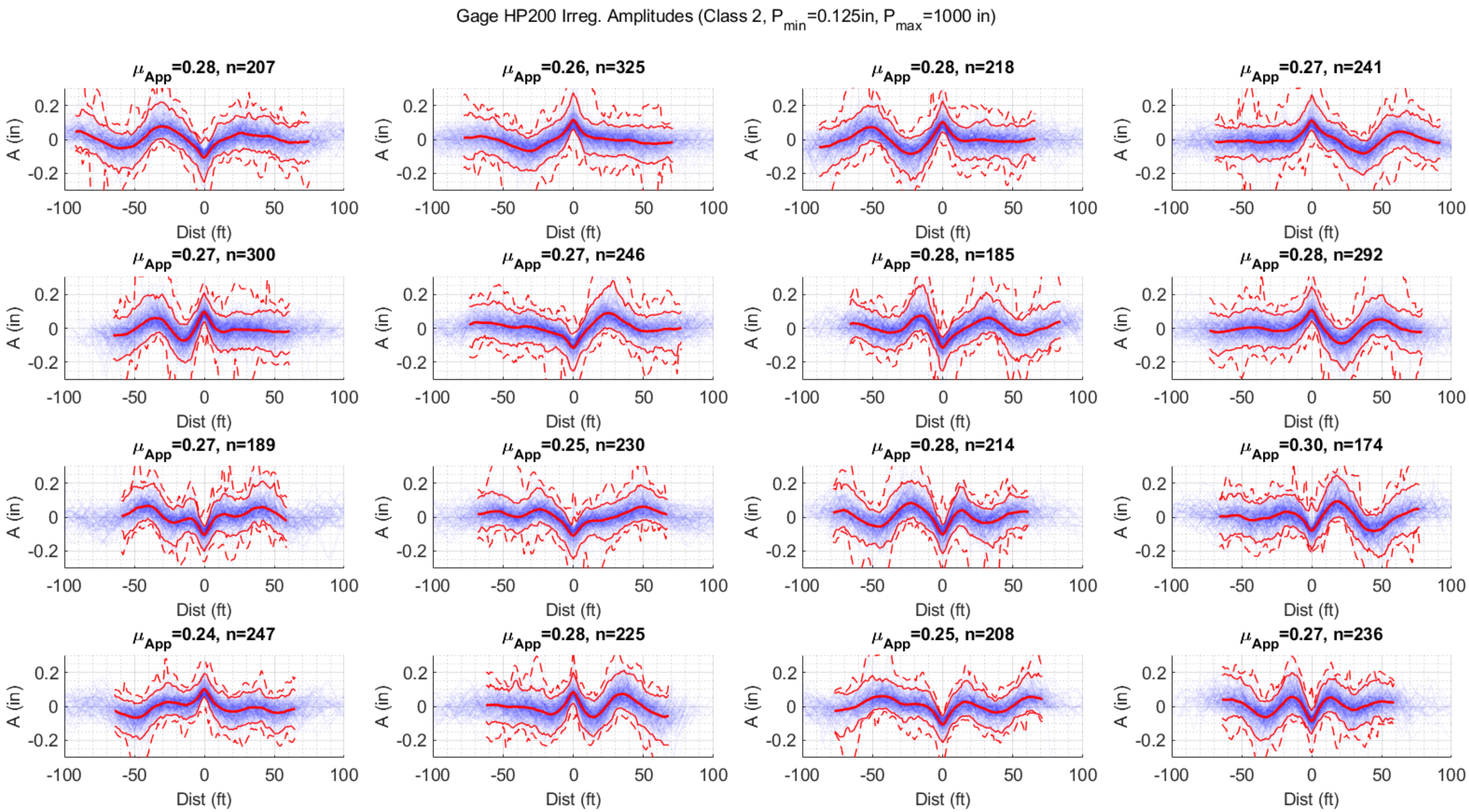

Figure 1. Gage irregularity clusters (Class 2 track)

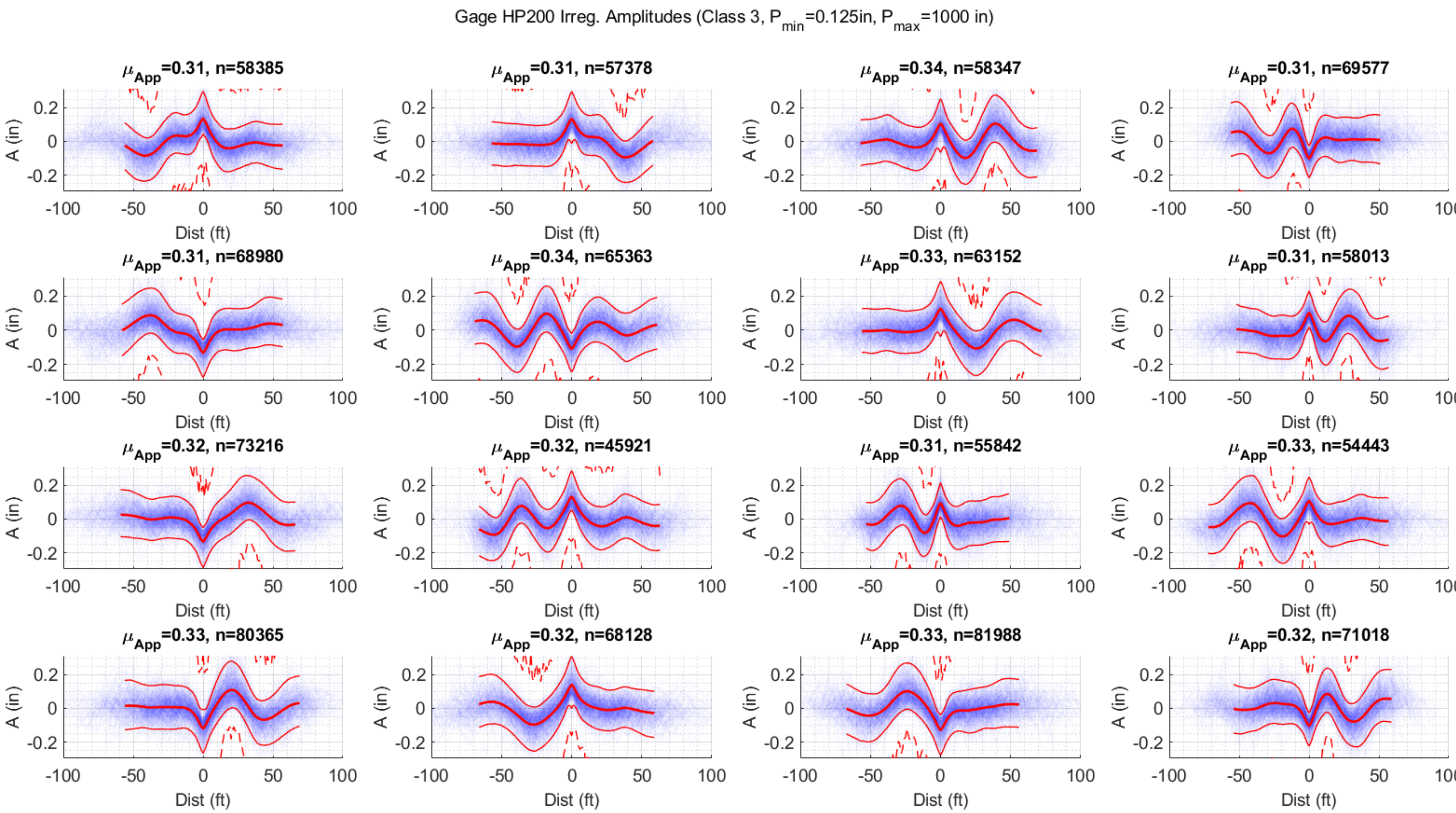

Figure 2. Gage irregularity clusters (Class 3 track)

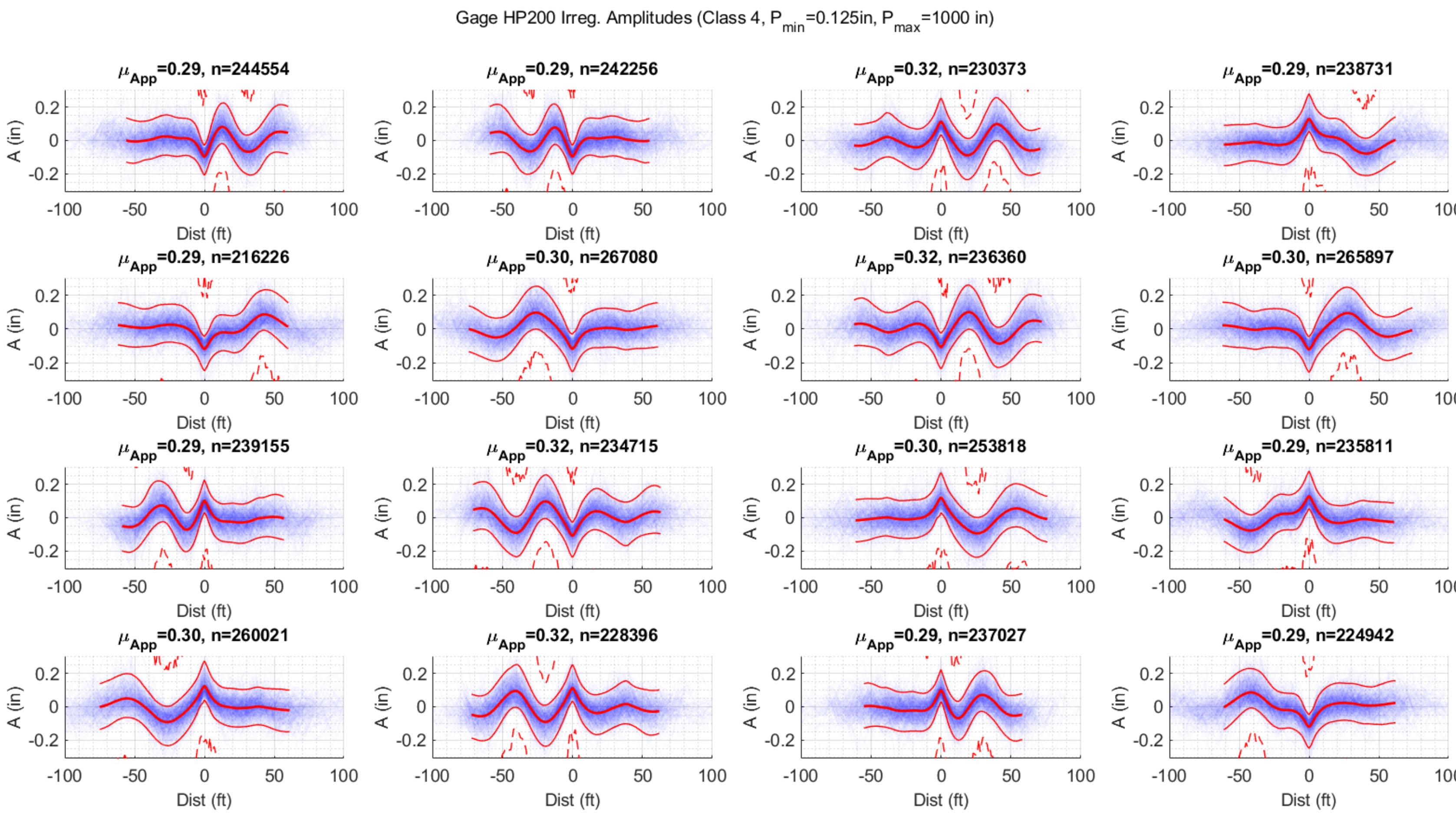

Figure 3. Gage irregularity clusters (Class 4 track)

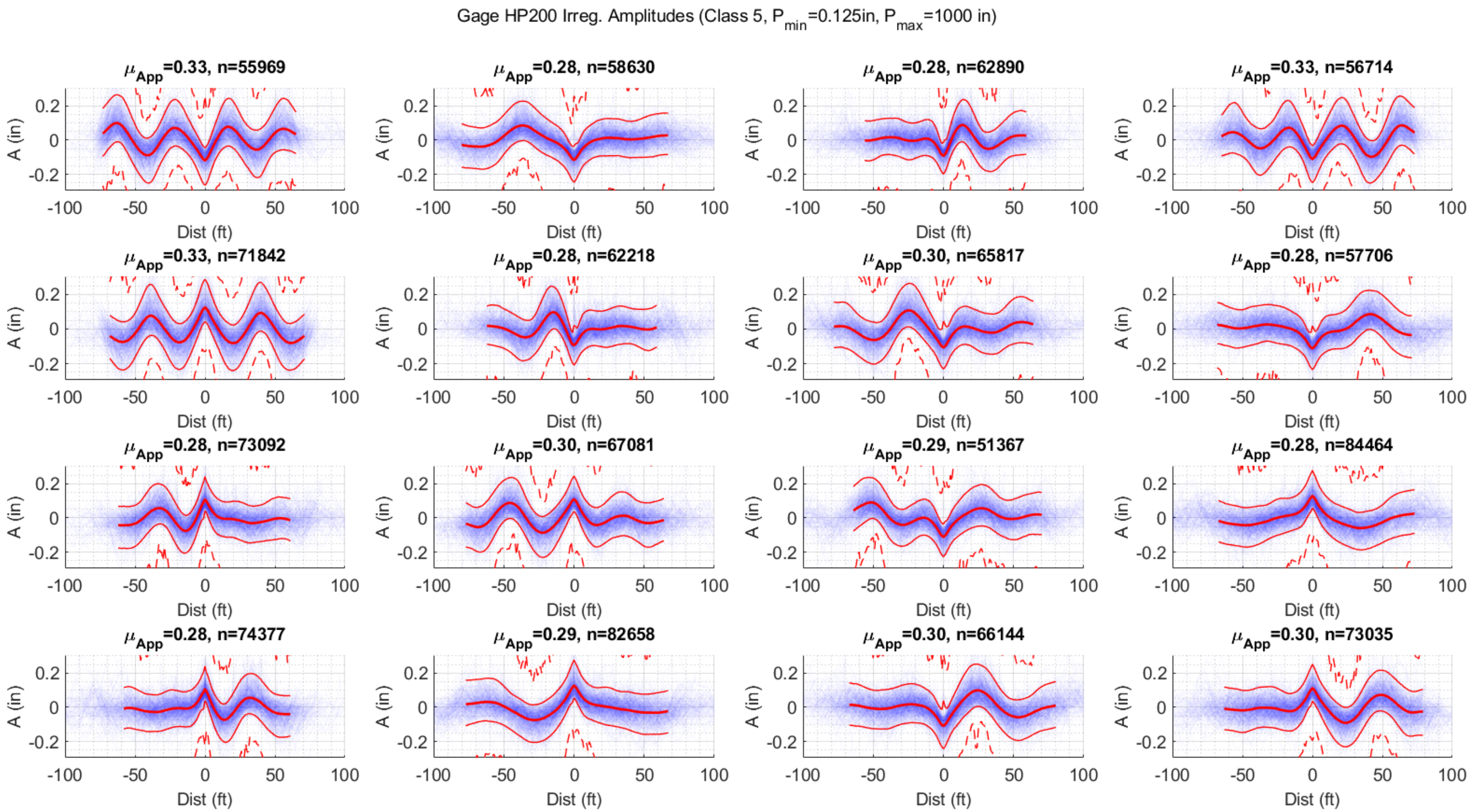

Figure 4. Gage irregularity clusters (Class 5 track)

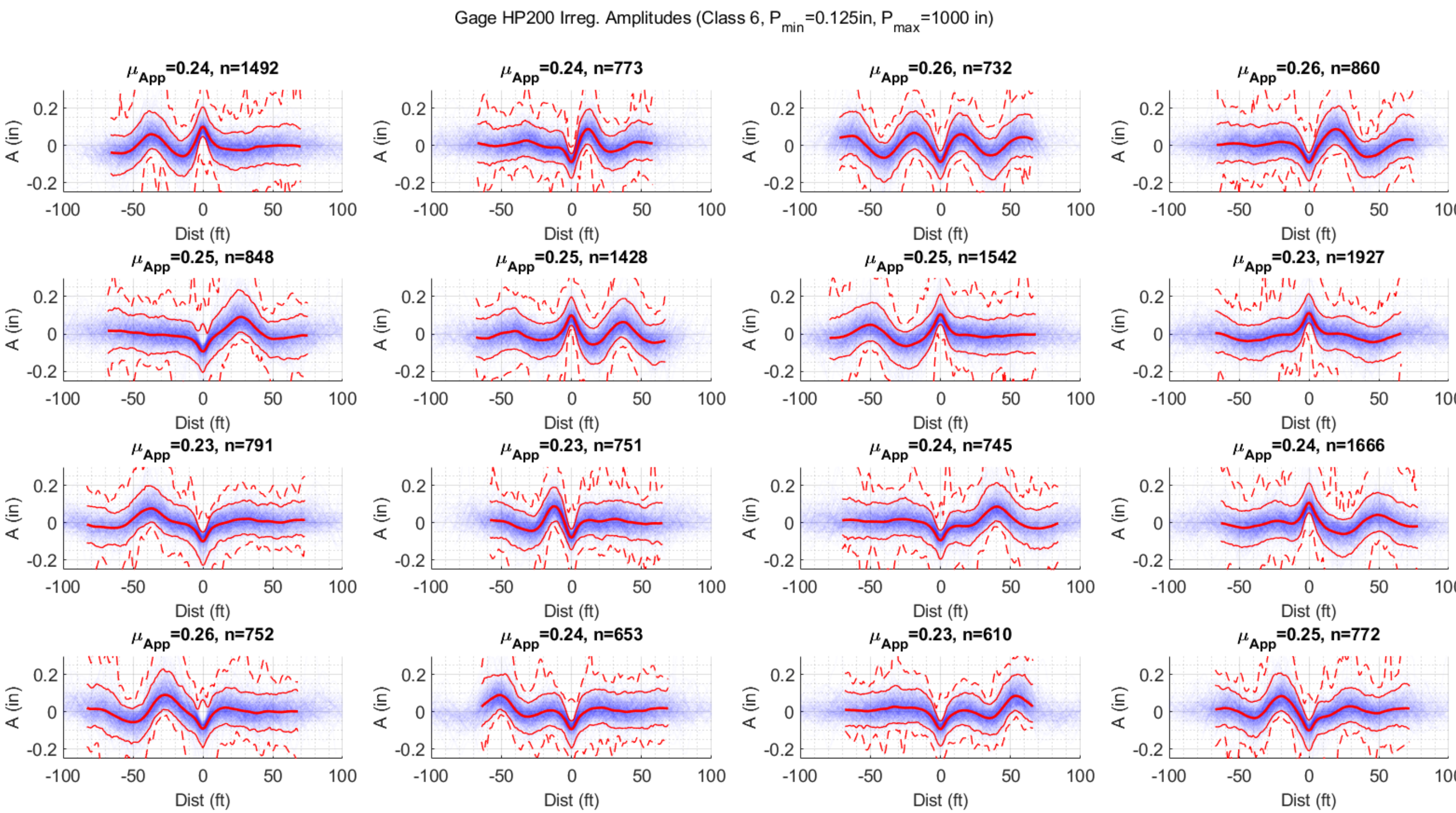

Figure 5. Gage irregularity clusters (Class 6 track)

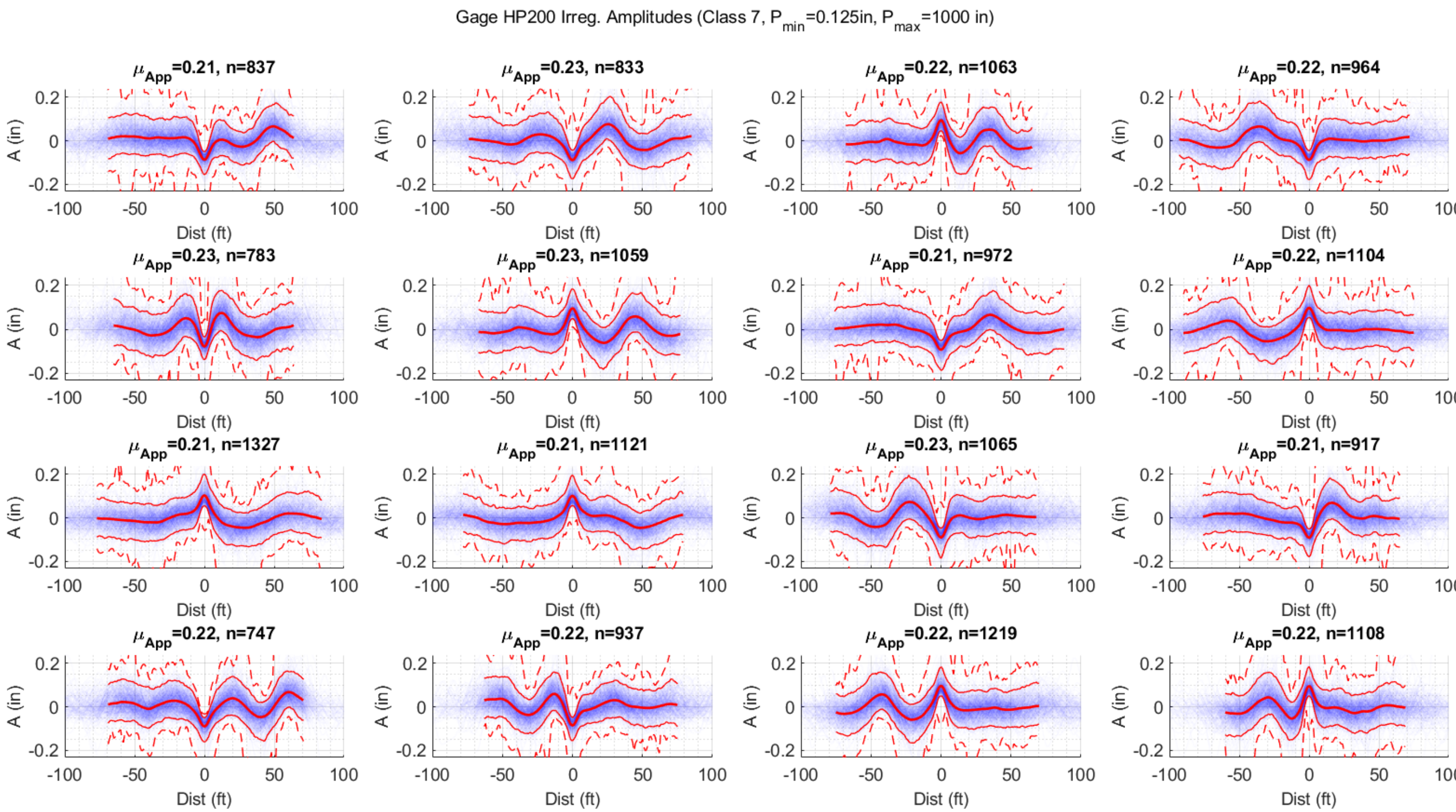

Figure 6. Gage irregularity clusters (Class 7 track)

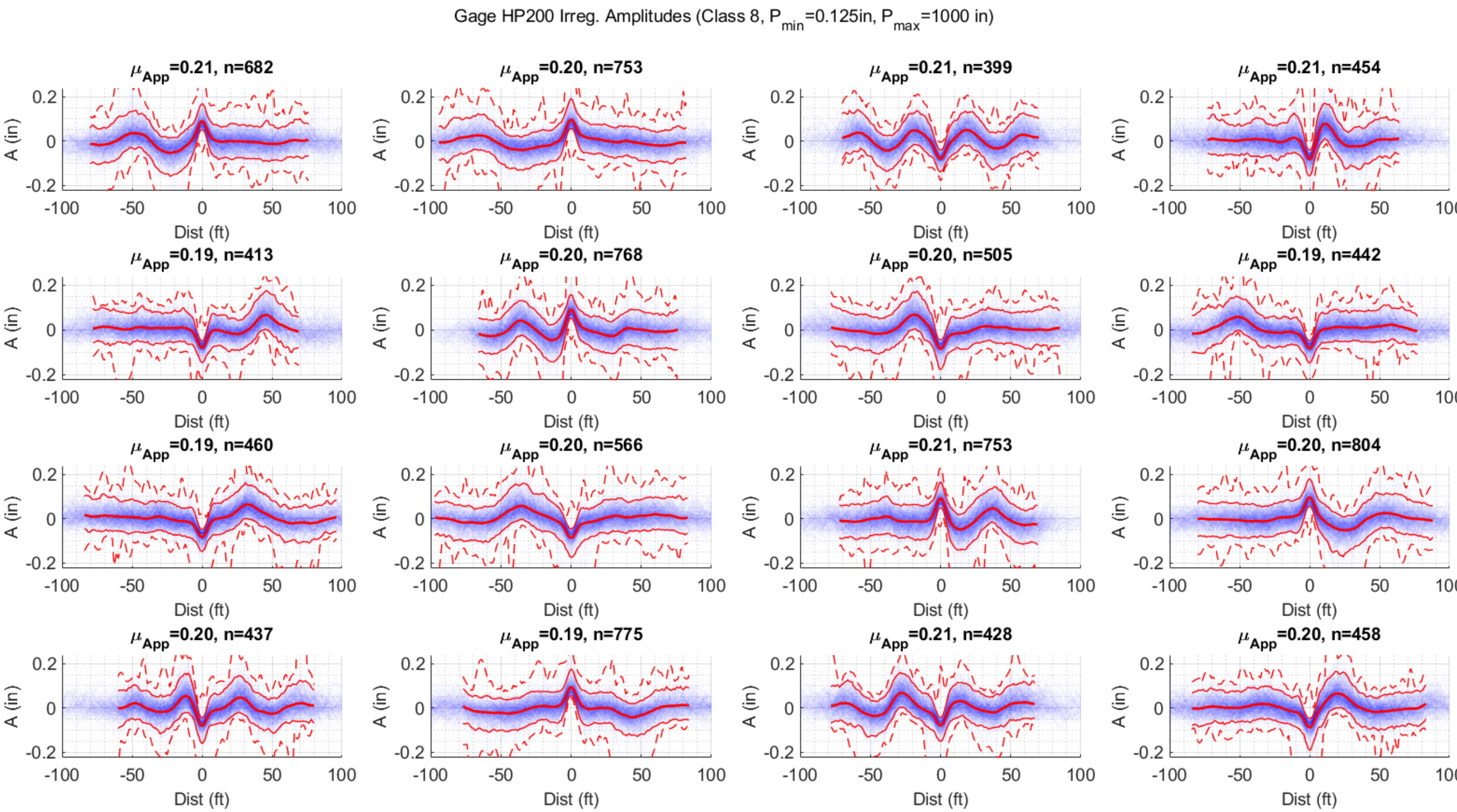

Figure 7. Gage irregularity clusters (Class 8 track)

Cross level (200-foot Filter)

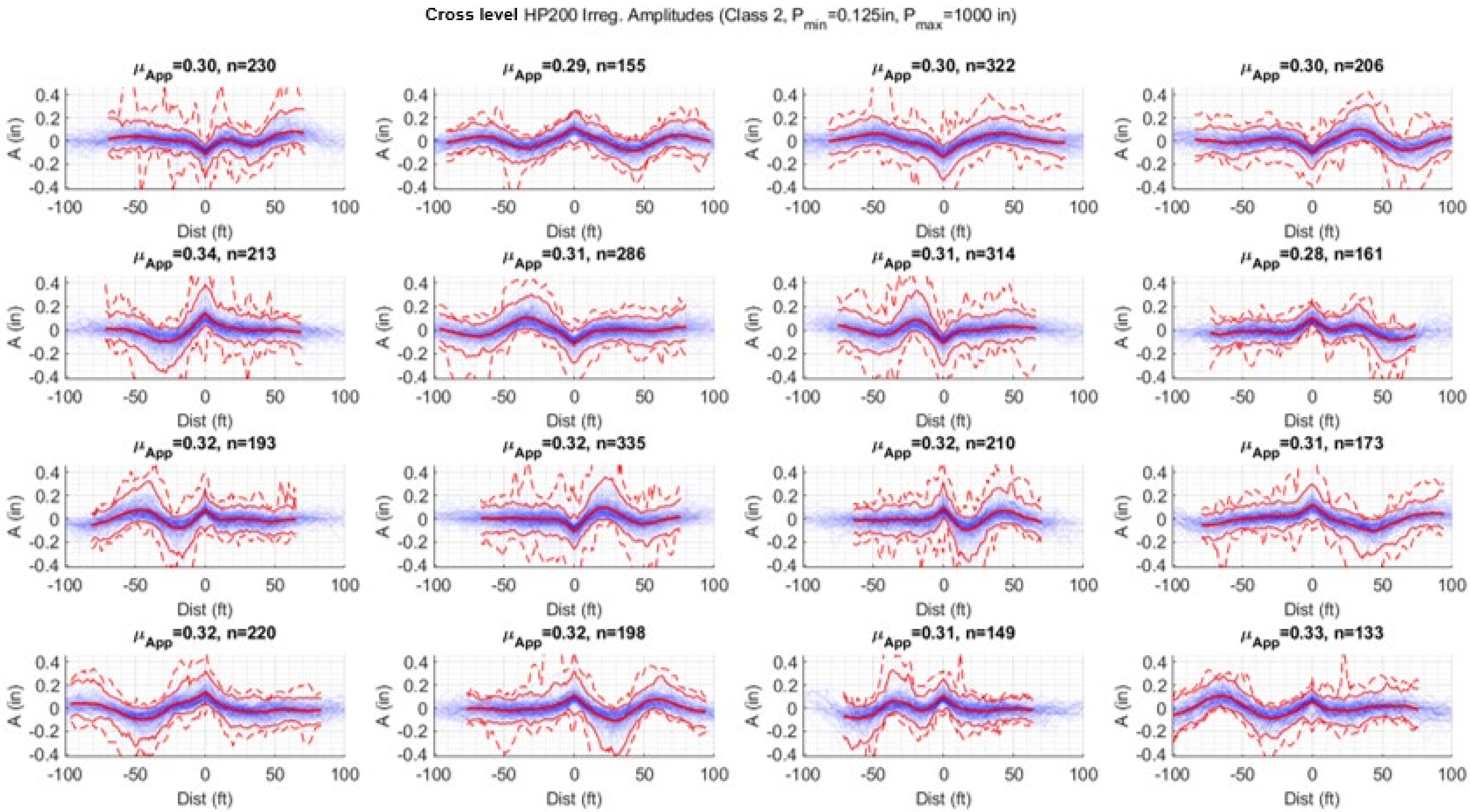

Figure 8. Cross level irregularity clusters (Class 2 track)

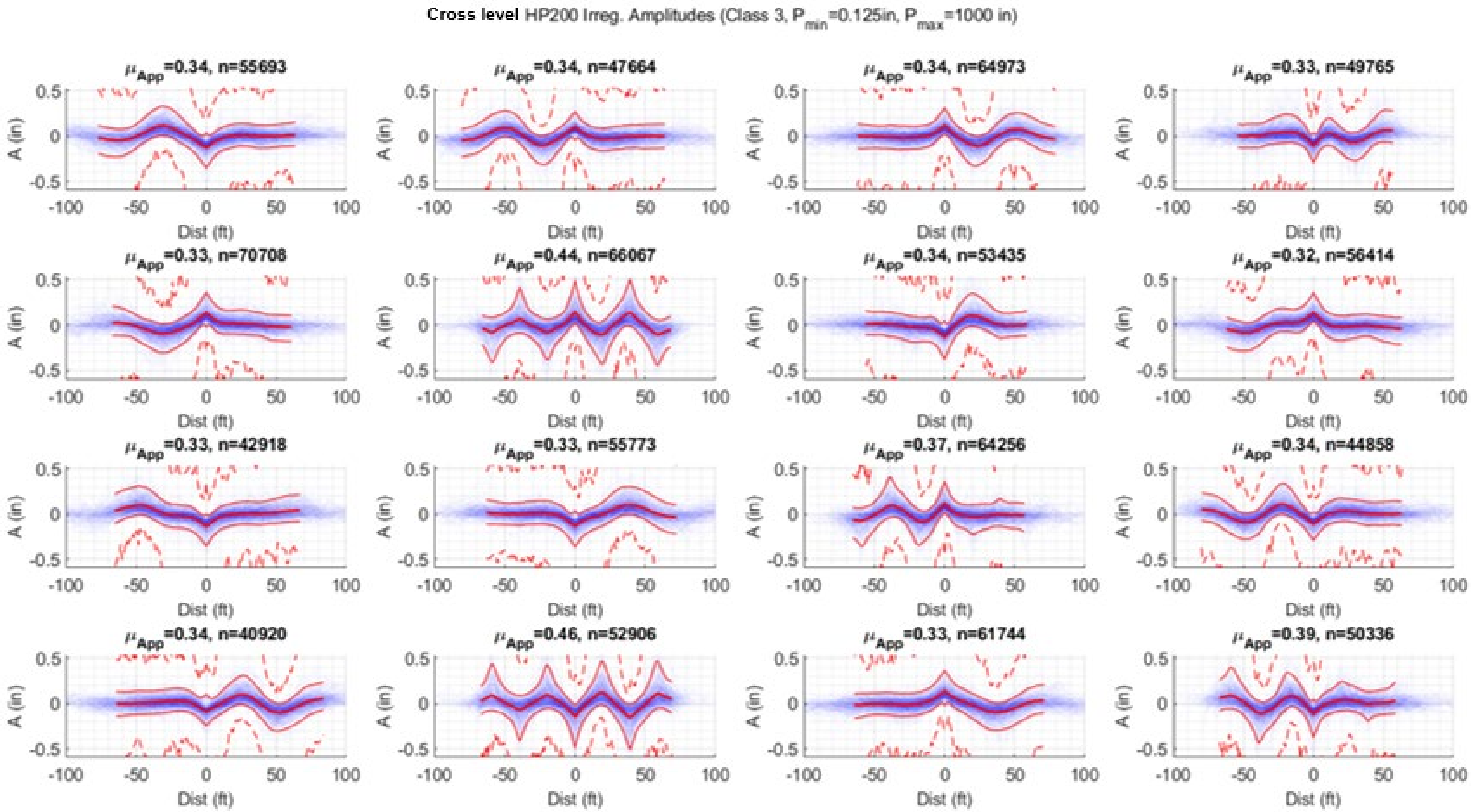

Figure 9. Cross level irregularity clusters (Class 3 track)

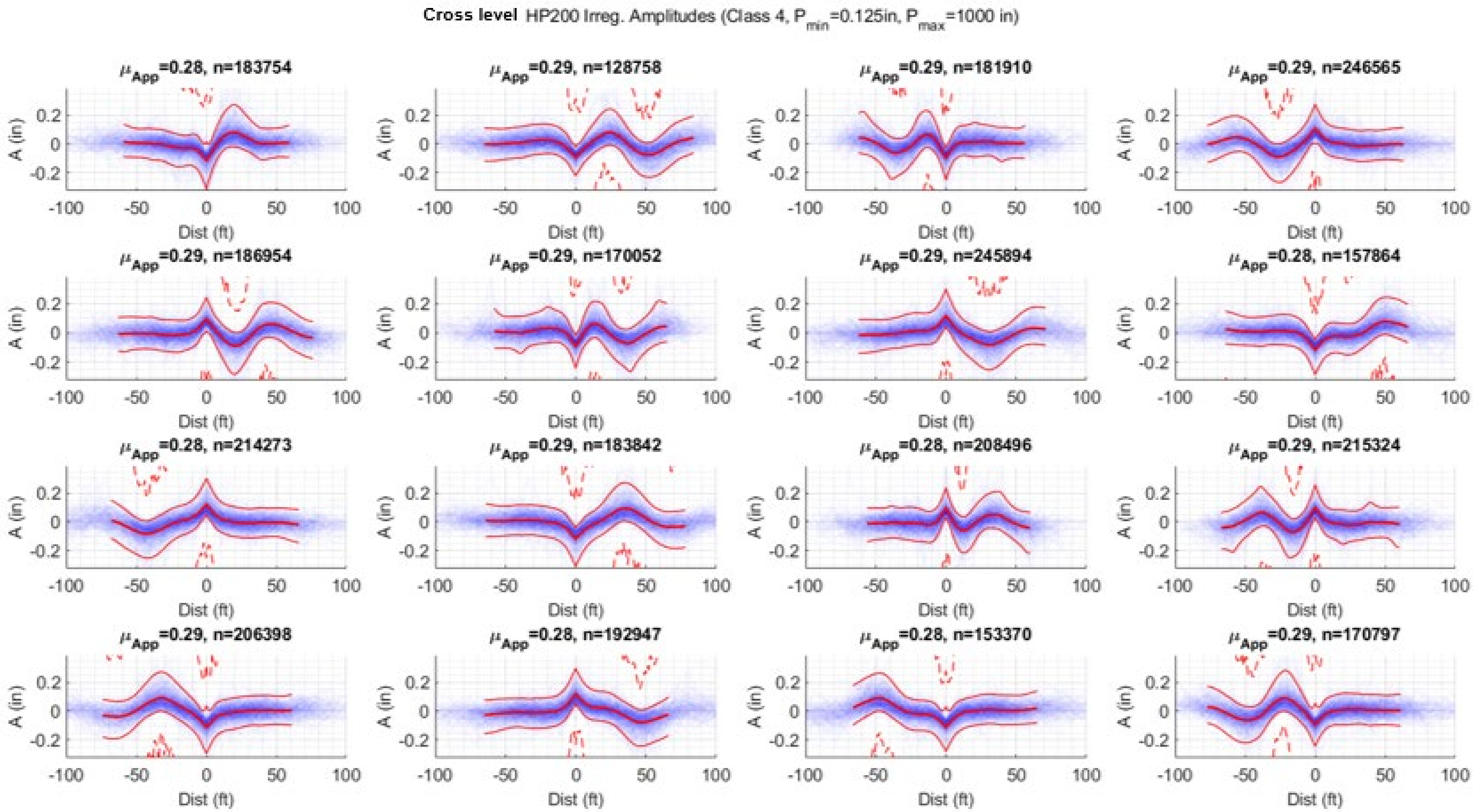

Figure 10. Cross level irregularity clusters (Class 4 track)

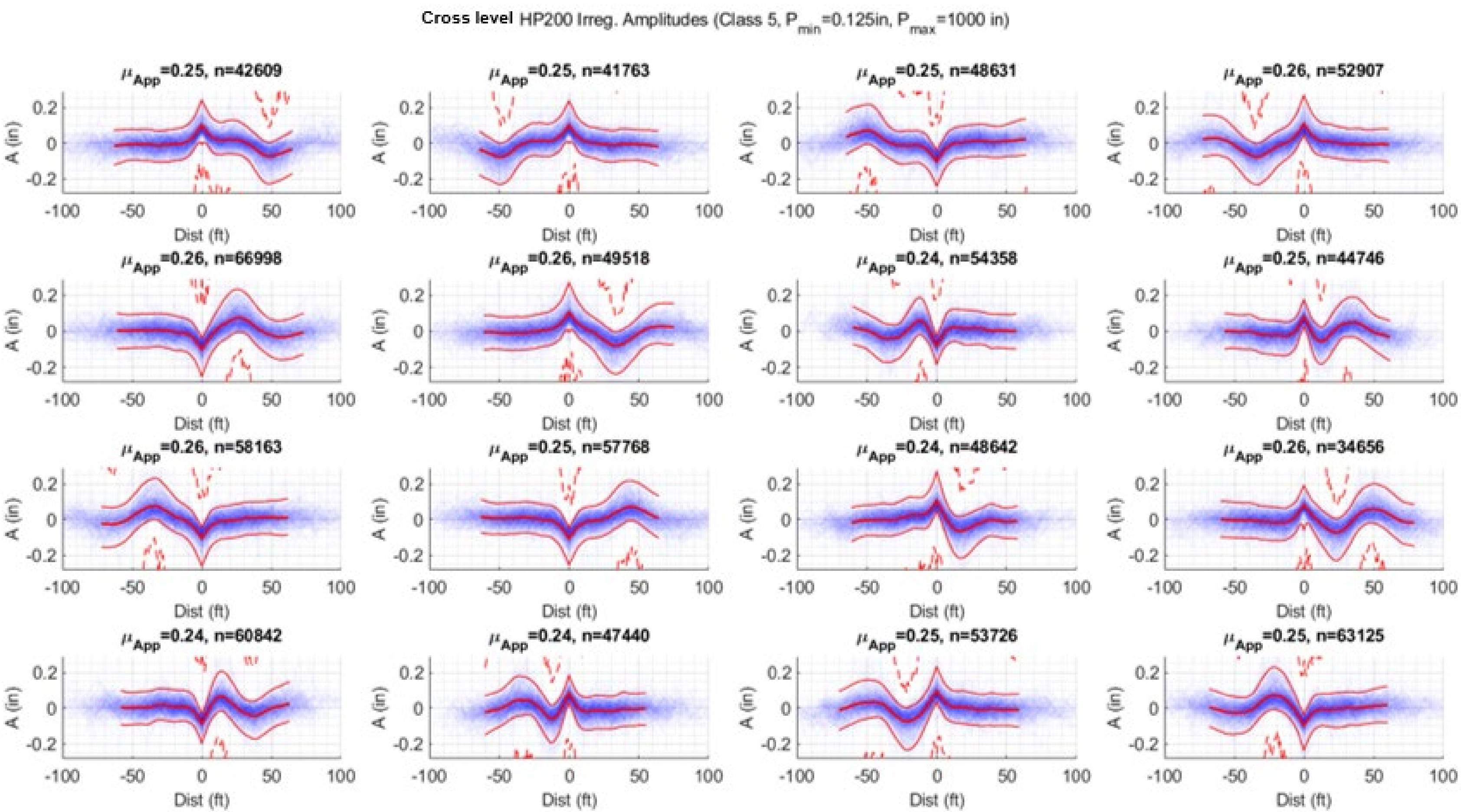

Figure 11. Cross level irregularity clusters (Class 5 track)

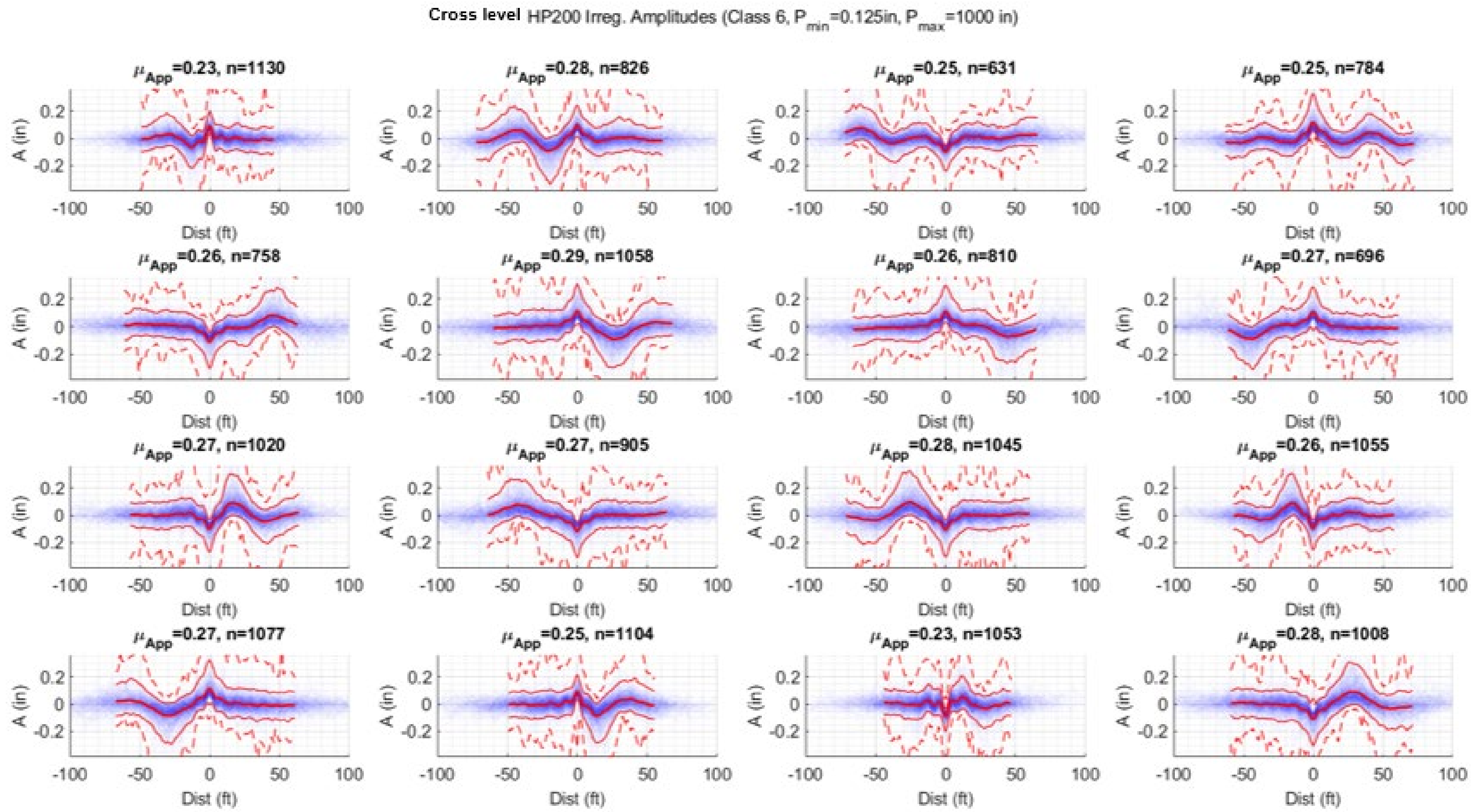

Figure 12. Cross level irregularity clusters (Class 6 track)

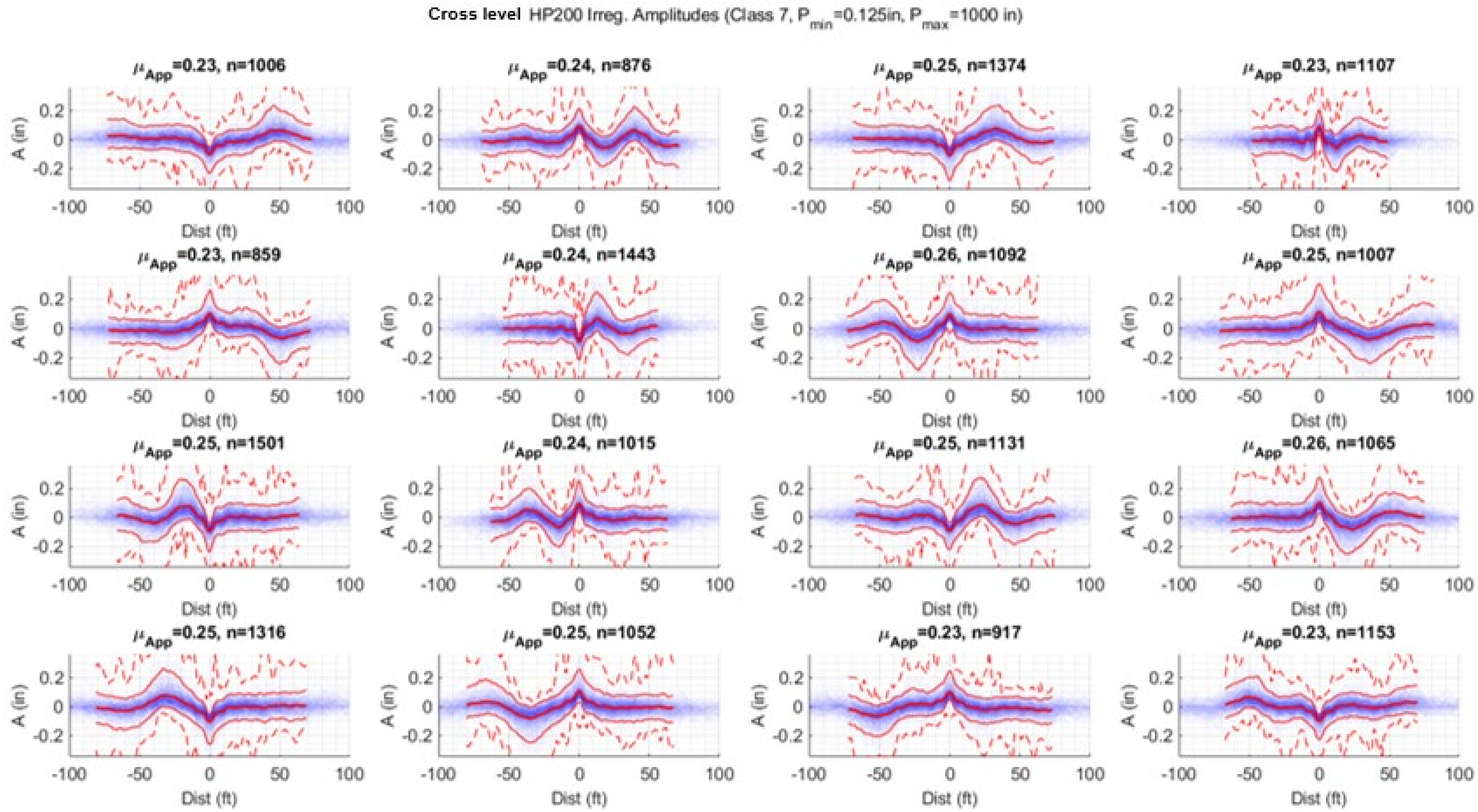

Figure 13. Cross level irregularity clusters (Class 7 track)

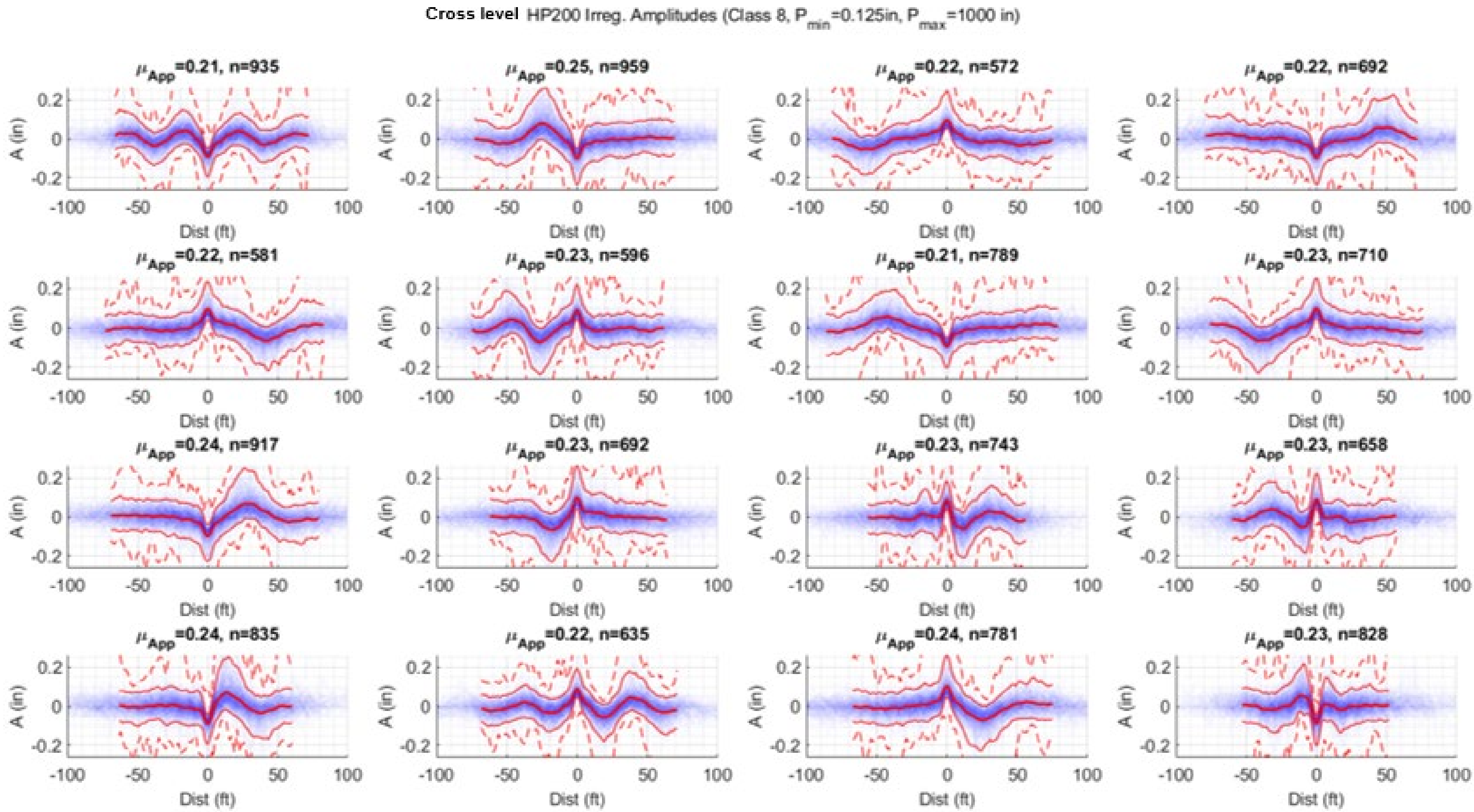

Figure 14. Cross level irregularity clusters (Class 8 track)

Left & Right Surface (200-foot Filter)

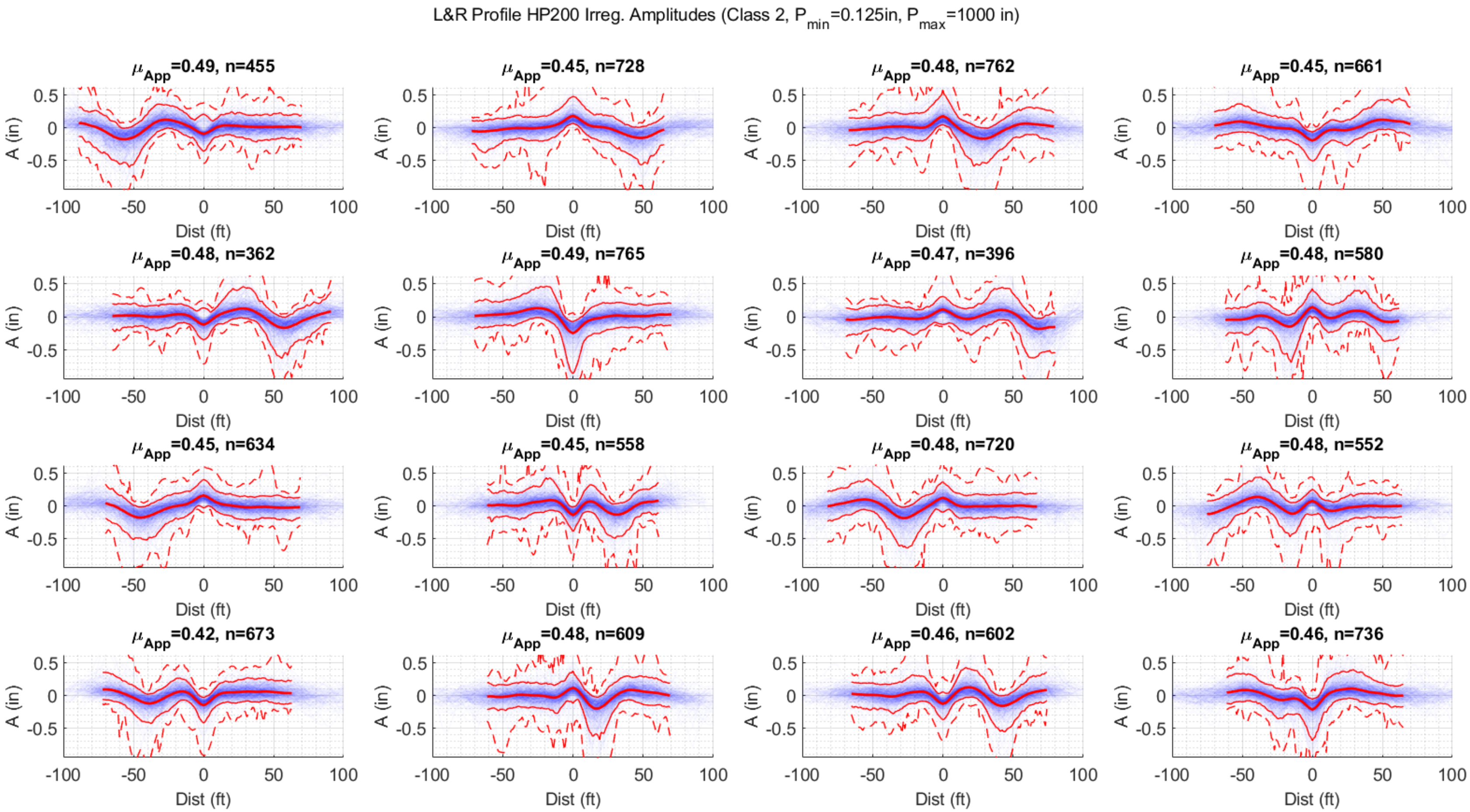

Figure 15. L&R rail surface irregularity clusters (Class 2 track)

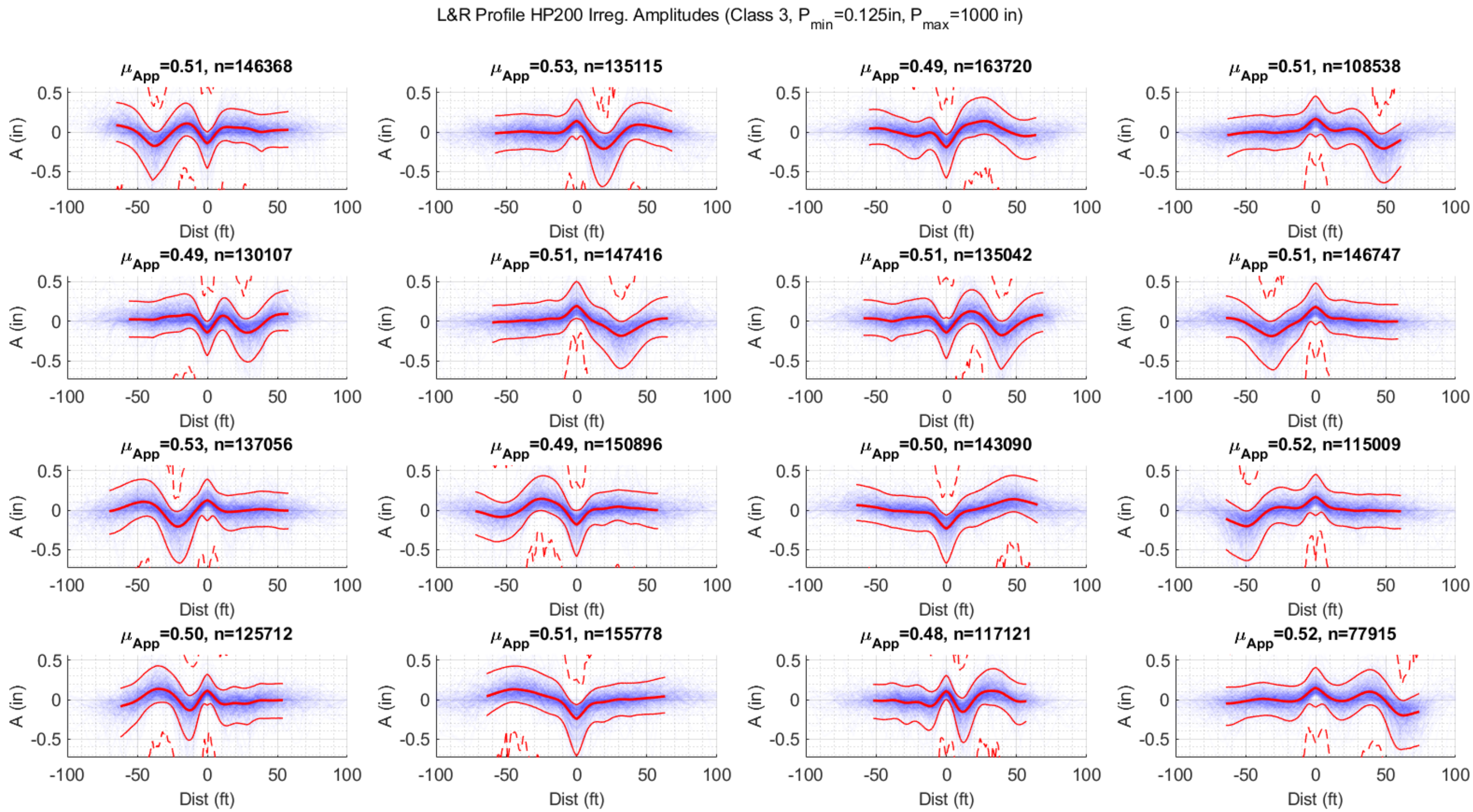

Figure 16. L&R rail surface irregularity clusters (Class 3 track)

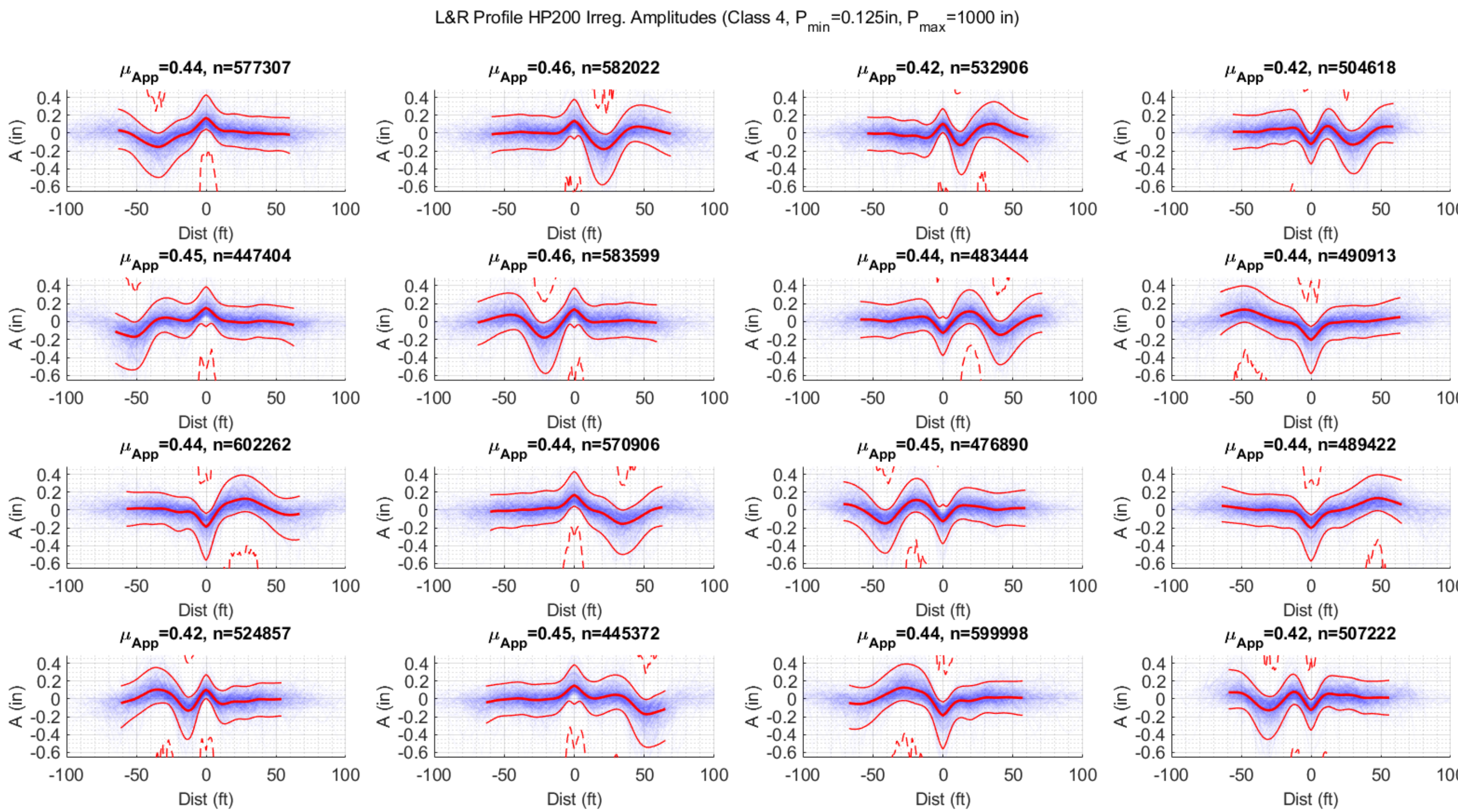

Figure 17. L&R rail surface irregularity clusters (Class 4 track)

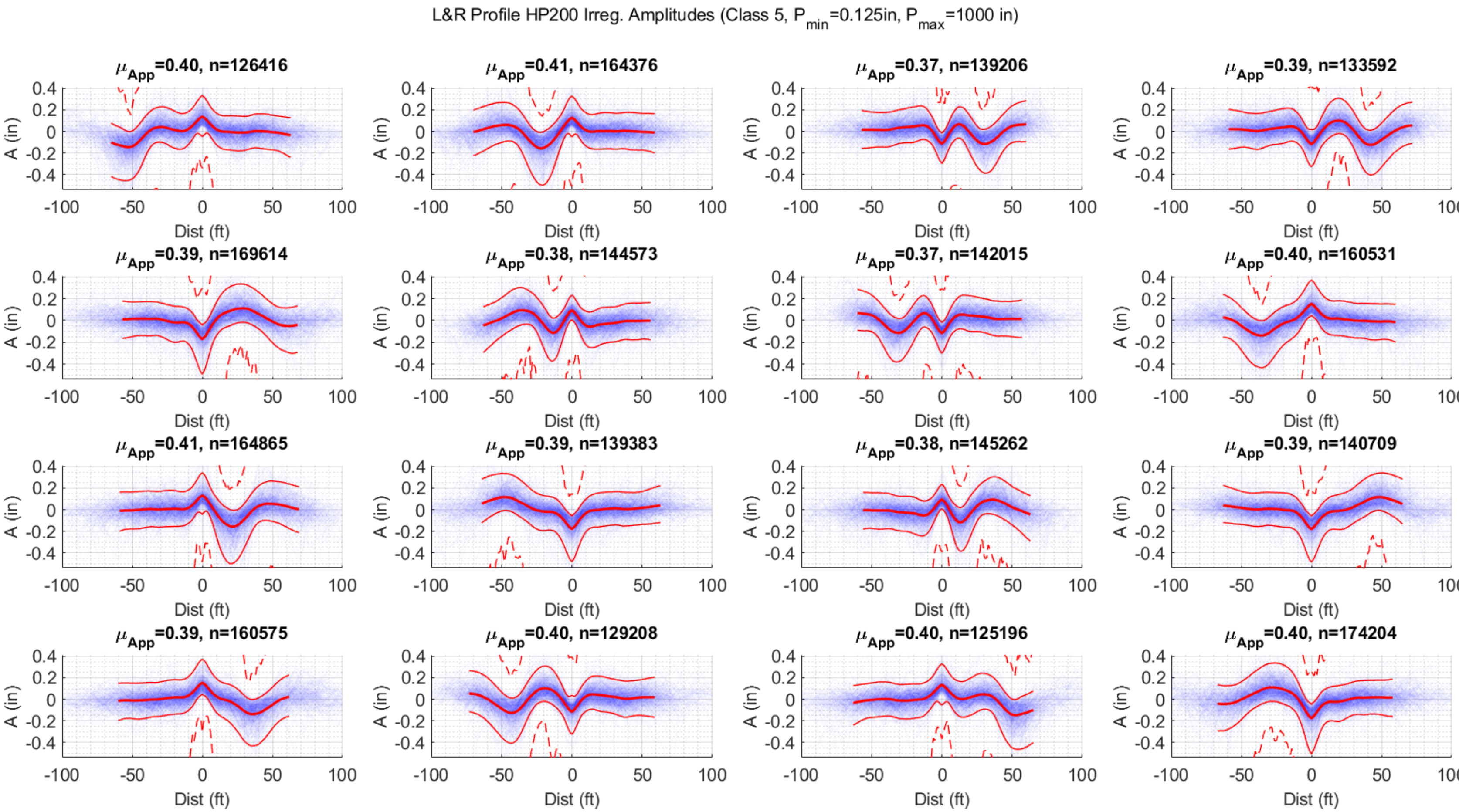

Figure 18. L&R rail surface irregularity clusters (Class 5 track)

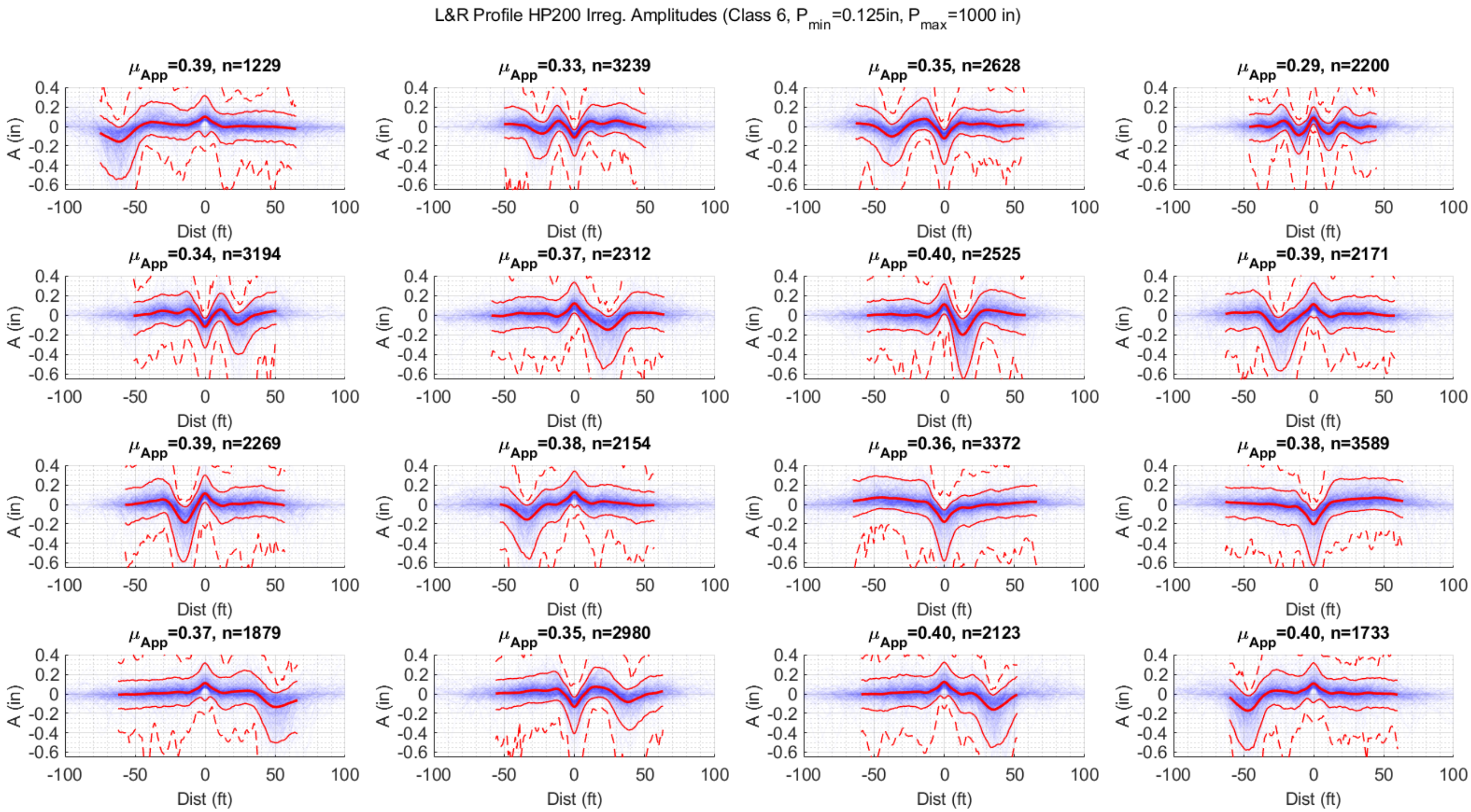

Figure 19. L&R rail surface irregularity clusters (Class 6 track)

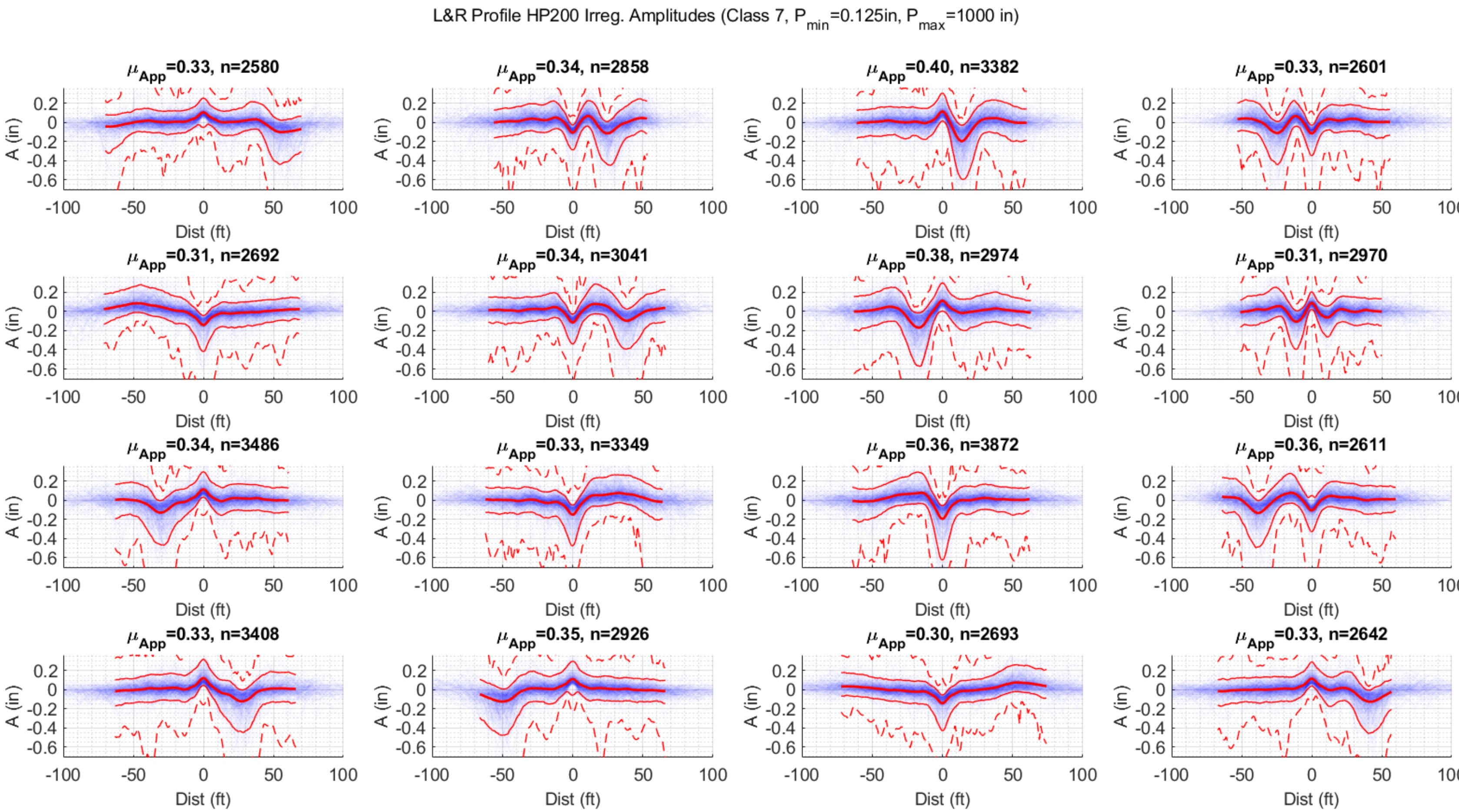

Figure 20. L&R rail surface irregularity clusters (Class 7 track)

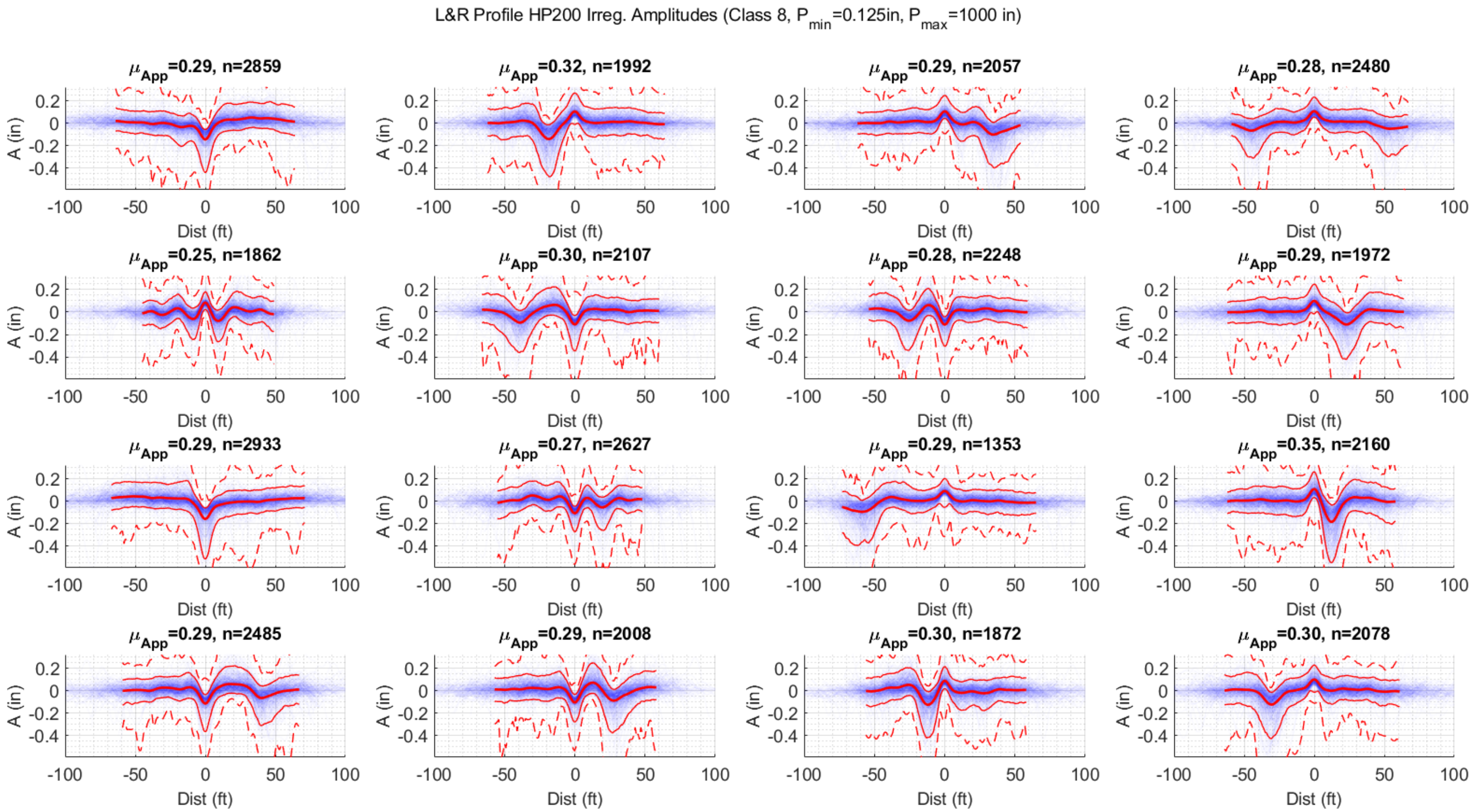

Figure 21. L&R rail surface irregularity clusters (Class 8 track)

Left & Right Alignment (200-foot Filter)

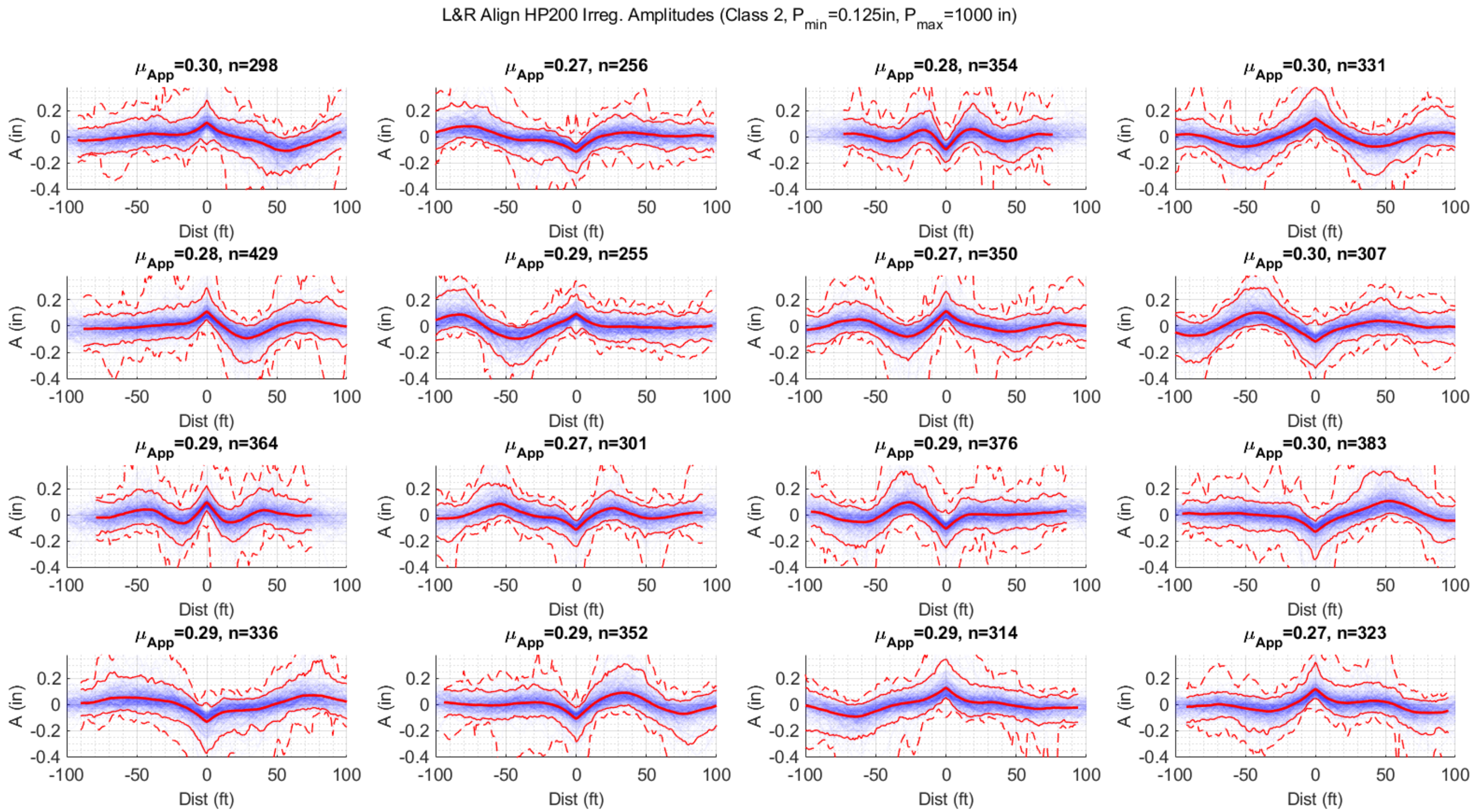

Figure 22. L&R rail alignment irregularity clusters (Class 2 track)

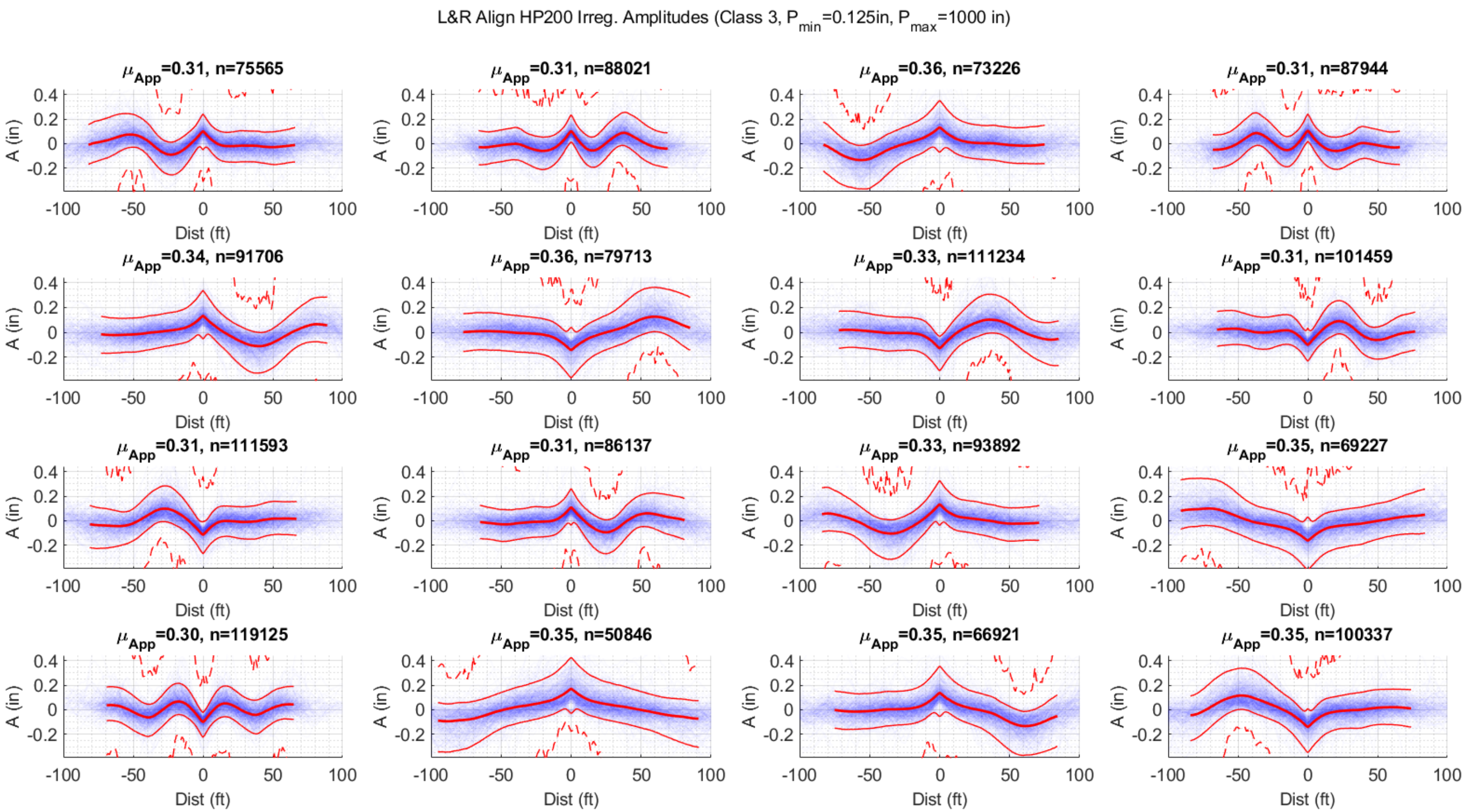

Figure 23. L&R rail alignment irregularity clusters (Class 3 track)

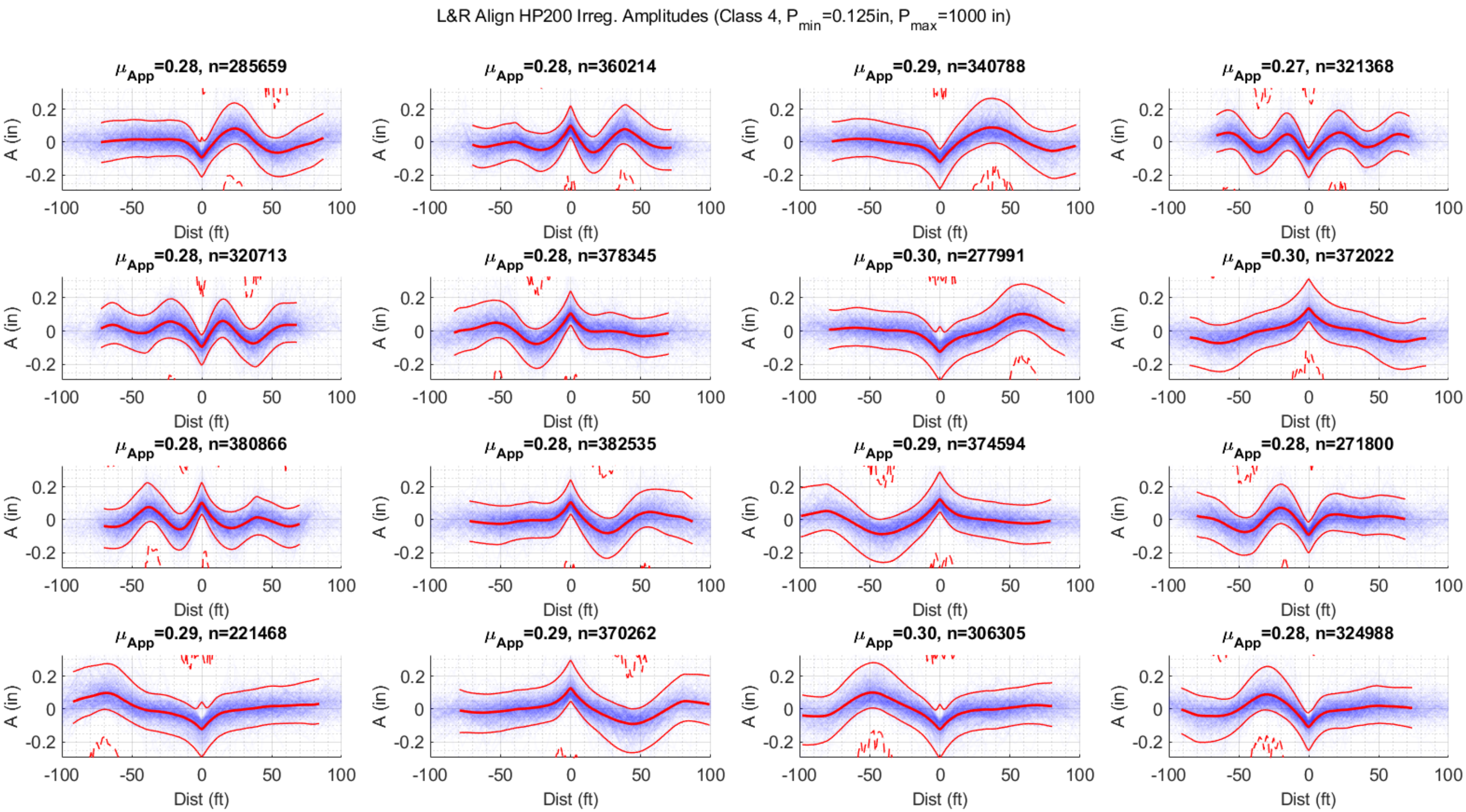

Figure 24. L&R rail alignment irregularity clusters (Class 4 track)

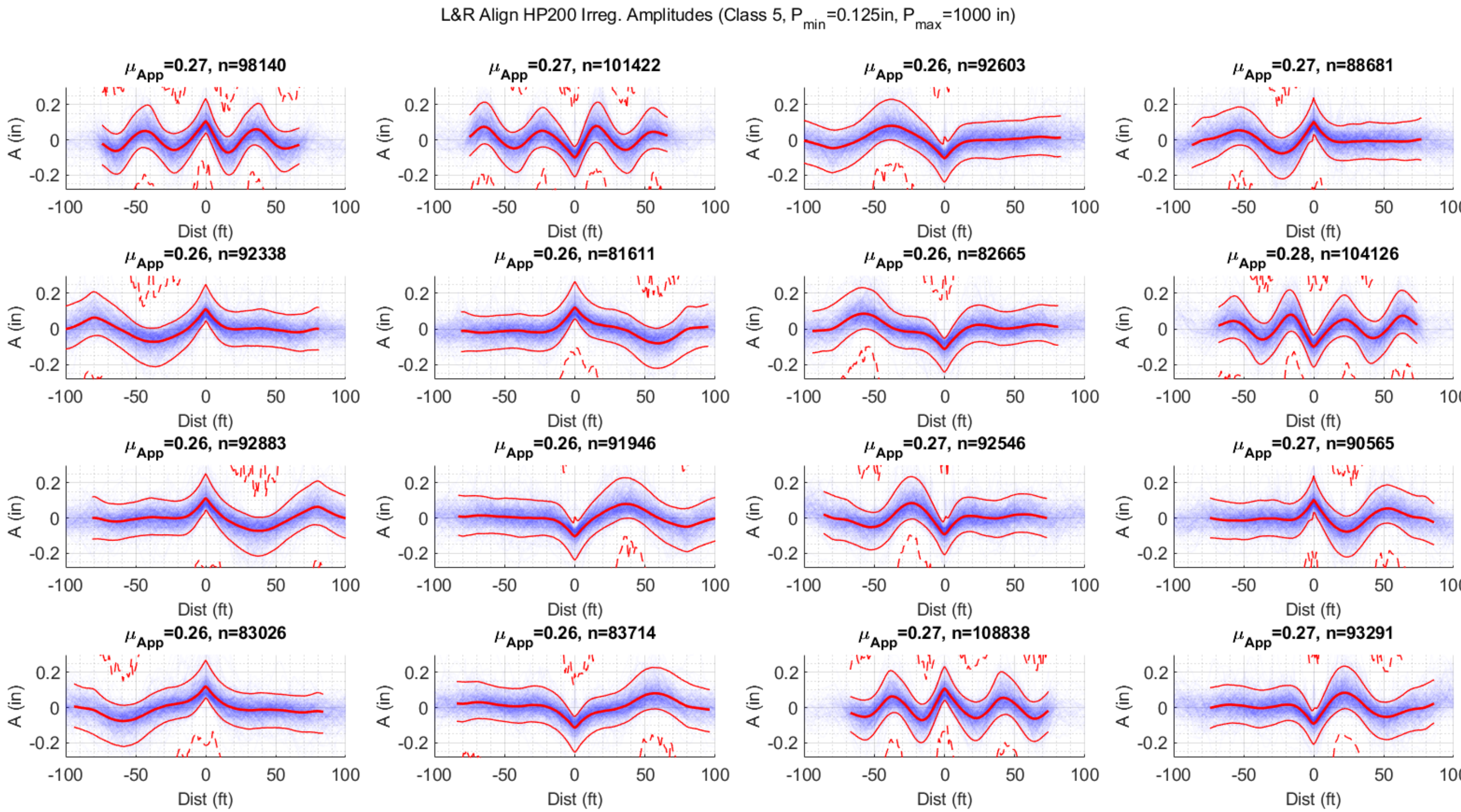

Figure 25. L&R rail alignment irregularity clusters (Class 5 track)

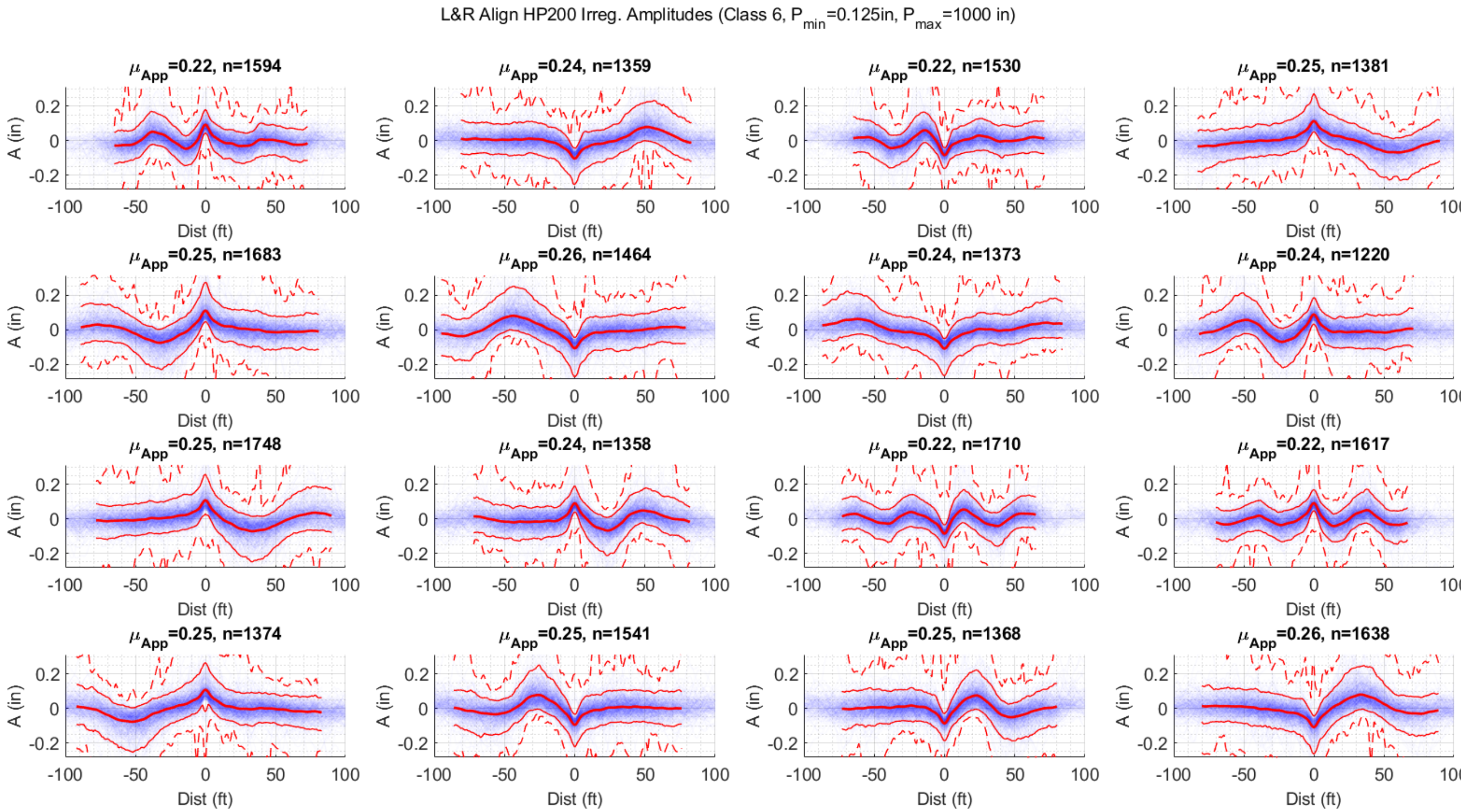

Figure 26. L&R rail alignment irregularity clusters (Class 6 track)

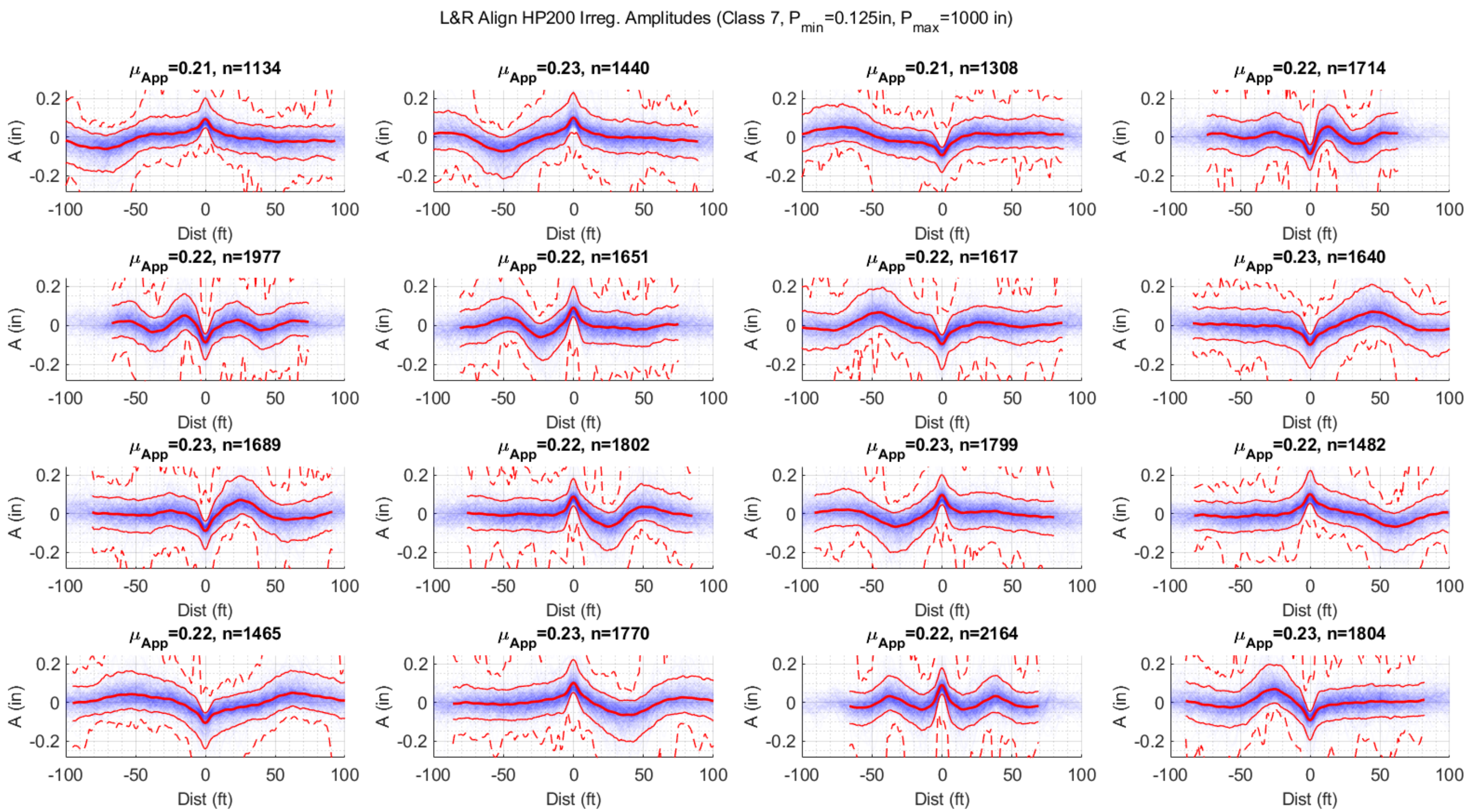

Figure 27. L&R rail alignment irregularity clusters (Class 7 track)

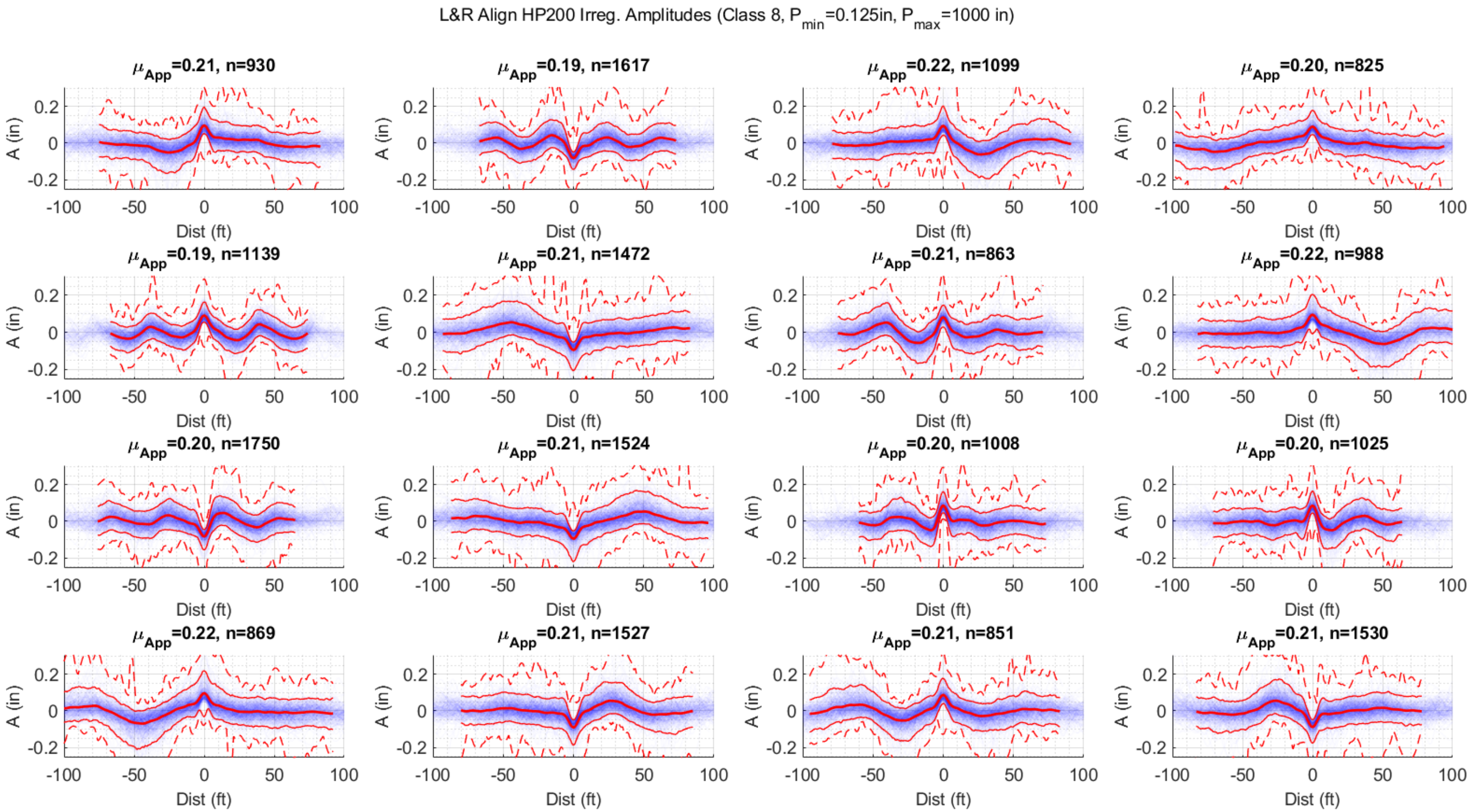

Figure 28. L&R rail alignment irregularity clusters (Class 8 track)

Appendix E.
Data from Various Track Geometry Cars

The PSD plot of gage by track class (Figure 17) shows that the PSD curves of different track classes are vertically shifted with respect to one another. The higher the track class, the lower its PSD curve on the graph, i.e., the more uniform the track gage. Meanwhile, the PSD plots of cross level (Figure 20), mean surface (Figure 22) and mean alignment (Figure 24) show a different pattern:

- At very short wavelengths (under 5 feet), PSD curves of Class 6–8 track are far below the PSD curves of Class 1–5 track, indicating a smoother, more uniform track geometry.
- At intermediate wavelengths (5–40 feet), PSD curves of Class 6–8 track are at or above those of Class 2–5 track, indicating less uniform track geometry in that frequency range.
- At long wavelengths (over 40 ft), PSD curves of Class 6–8 track are again below the PSD curves of Class 1–5 track, indicating a more uniform track geometry.

This pattern differs from other studies that show that higher track classes have more uniform TG at all frequencies (Section 6.4.2).

Likewise, the coherence of certain TG variables for Class 6–8 track (Figure 29) is very different from other track classes (Figure 28), contradicting other studies.

It is possible that these patterns are not purely functions of track class. Rather, they may also reflect the differences between different geographical regions or between different track geometry cars. Consider the following factors:

- Most TG data from Classes 1–5 analyzed in this study was measured by the FRA ATIP car fleet (DOTX 216, 217, 218, 219, and 220), while most of the data for Class 6–8 data, concentrated in the Northeast Corridor, was measured by an Amtrak track geometry car.
- The PSD plots do not show drastic differences between the different geographical regions within the same track class, except for the Northeast Corridor (see Appendix C–Figure 3, Appendix C–Figure 8, Appendix C–Figure 13, and Appendix C–Figure 18).
- The PSD plots for Class 4 track that analyze substantial mileage measured by both ATIP and Amtrak vehicles show significant differences between the data from the ATIP and Amtrak cars (Appendix E–Figure 1).

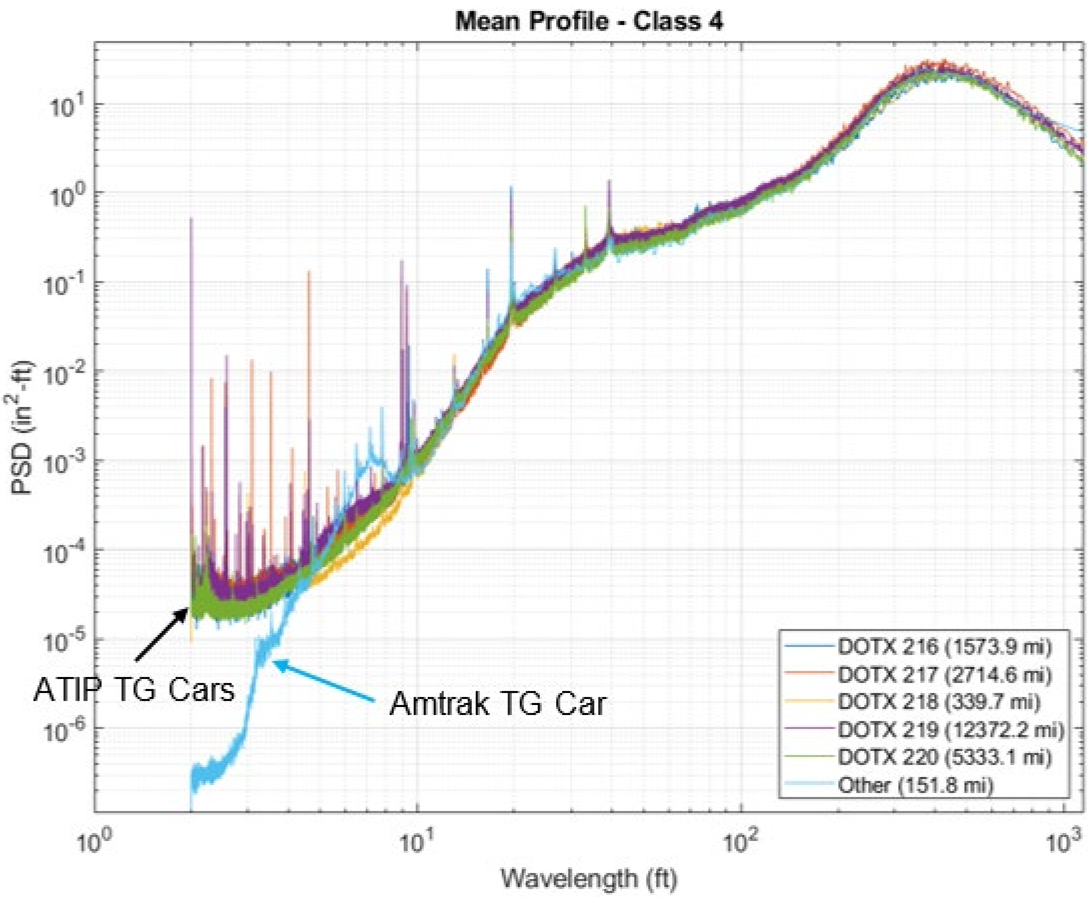

Figure 1. PSD of mean surface (Class 4 track) separated by TG car

- One of the methods used to verify an internal consistency of a TGMS involves the calculation of a transfer function (TF) between the measured cross level and the difference between the left and right rail surface (i.e., Euronorm EN 13848). This TF is expected to have a magnitude of 1 and a phase angle of 0 within the bandwidth specified by the TGMS manufacturer. In TG data from FRA ATIP cars, the magnitude of this TF is close to 1, and the phase angle is close to 0 for spatial frequencies between 0.0025 and 0.1 feet^{-1} that correspond to wavelengths between 10 and 400 feet (Appendix E–Figure 2). In the TG data from the Amtrak car, the magnitude and phase angle of this TF fluctuate (Appendix E–Figure 3).

Therefore, caution is advised when making conclusions about the Class 6–8 track geometry that is presented and discussed in this report.

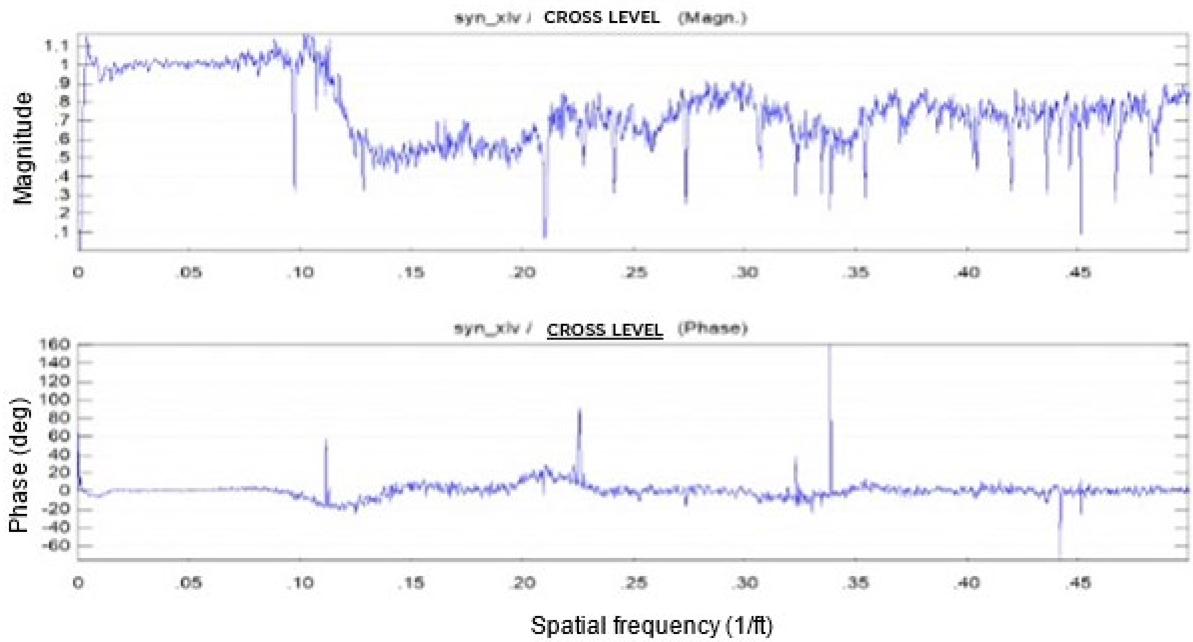

Figure 2. Vertical cross-check TF calculated from TG data (ATIP TG car)

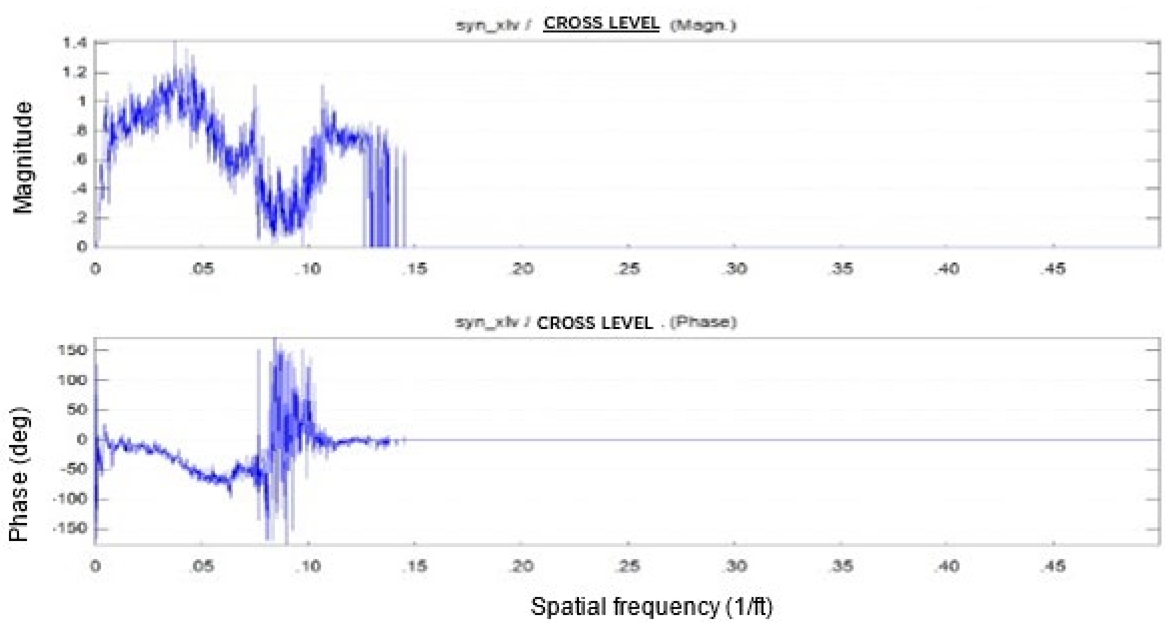

Figure 3. Vertical cross-check TF calculated from TG data (Amtrak TG car)

Abbreviations and Acronyms

ACRONYM	DEFINITION
ASCII	American Standard Code for Information Interchange
ATIP	Automated Track Inspection Program
CDF	Cumulative Density Function
CPSD	Cross-Power Spectral Density
CWR	Continuous Welded Rail
CWT	Continuous Wavelet Transform
ERRI	European Rail Research Institute
FFT	Fast Fourier transform
FRA	Federal Railroad Administration
IQR	Interquartile range
MCO	Mid-Chord Offset
NEA	Northeast Area of the US
NEC	Northeast Corridor
PDF	Probability Density Function
PSD	Power Spectral Density
RAM	Random Access Memory
STFT	Short-Time Fourier transform
TF	Transfer Function
TG	Track Geometry
TGMS	Track Geometry Measurement System
TQI	Track Quality Index
TSD	Track Surveying Device
TTC	Transportation Technology Center
TTCI	Transportation Technology Center, Inc.
WRM	Wheel/Rail Mechanism