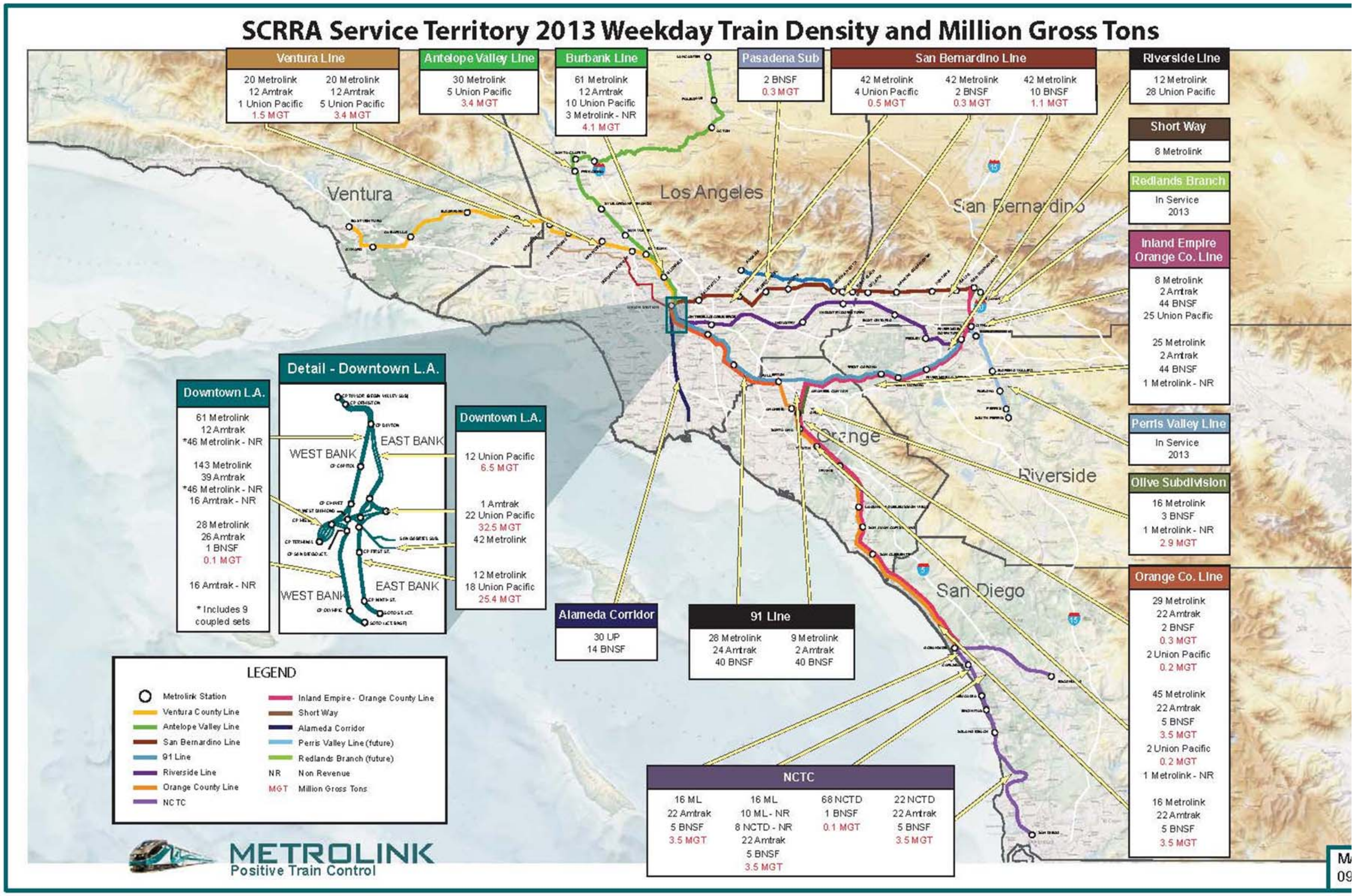
Automated Condition Assessment as an Aid to Complying With the FTA State of Good Repair Regulations

Metrolink Overview

Commuter Railroad with Mixed Passenger and Freight Traffic

1. Most lines are former secondary main tracks built between 1875 and 1900. Freight, Amtrak and commuter trains operate across system. Commuter trains use push-pull operation.
2. Peak commuting hours are 5:00 am to 9:00 am in the morning, and 3:00 pm to 7:00 pm in the evening. Freight primarily operates mid-day and at night.
3. Most track has been reconstructed since original purchase. Standard rail section is 136 RE with some 115 RE and 119 RE remaining on former AT&SF lines.
4. Ties are 1/3 concrete and 2/3 wood.
5. FRA Class 5 track with maximum speed of 90 mph.

SCRRA Lines and Traffic Density



Regulatory Background for Condition Assessment

The Moving Ahead for Progress in the 21st Century Act ("MAP-21"), enacted in 2012, established requirements for recipients of federal funding to meet certain requirements for ensuring a "state of good repair" of their systems.

Through regulation, FTA will establish a national transit asset management system. The regulation will:

1. **Define "State of Good Repair."**
2. **Set objective standards for measuring the condition of capital assets.**
3. **Establish performance measures for "state of good repair," under which all FTA grantees will be required to set targets.**

FTA Requirements for Condition Assessment, Concluded

All FTA grantees and their sub-recipients will be required to develop transit asset management plans that include, at a minimum:

1. Capital asset inventories and condition assessments.
2. Investment prioritization.

Each designated recipient of FTA formula funding will be required to report on:

1. The condition of their system.
2. Any change in condition since the last report.
3. Targets set under the above performance measures.
4. Progress toward meeting the performance targets.

Additional Considerations for State of Good Repair

Accounting Requirements

- SCRRA follows the Governmental Accounting Standards Board Statement 34 – <u>Basic Financial Statements and Management's Discussion and Analysis for State and Local Governments</u>.
- Under GASB 34, SCRRA does not depreciate network assets as an annual operating expense but uses an approach similar to the FTA concept of "state of good repair."
- GASB 34 requires an assessment of the condition of network assets at least every three years.
- Condition assessments must demonstrate that assets are being preserved approximately at (or above) the established condition level.
- The next slide shows the definitions of each condition level adopted by SCRRA.

Condition and Quality Ranges

SCRRA adopted a condition scale ranging from 50 to 100 in the five categories below. Like SCRRA, FTA is expected to establish a rating scale containing five divisions.

1. **Excellent (90+) – An asset that exhibits no conditions of wear or degradation, essentially a "like new" condition.**
2. **Good (80 to 89) – An asset rated as good will require maintenance but is not expected to require replacement for the next five years.**
3. **Fair (70 to 79) – An asset rated as fair is in serviceable condition at the time of the rating, but will require replacement within 5 years.**
4. **Poor (60 to 69) – An asset that is operating at less than full capacity (e.g. a speed restriction is imposed) and that will require replacement of at least one component to return to full capacity.**
5. **Critical (59 or below) – An asset requiring rehabilitation within the year in order to continue operating.**

Industry Practice for Condition Assessment

Whether required by regulation or not, the ability to measure and report on the condition of an asset is good practice.

1. **The railroad industry is moving toward automated systems for inspection and condition assessment.**
2. **Automated systems provide a rapid and accurate method for assessing the condition of track and rolling stock.**
3. **Data collected automatically is transferred directly to a database.**
4. **A computer program does the numerical and statistical analysis i.e. the "number crunching."**
5. **Using the information provided by the automated analysis, management focuses on planning and prioritization of investment.**

Automated Assessment Systems

Currently, systems exist for measurement or assessment of several characteristics of the track, including:

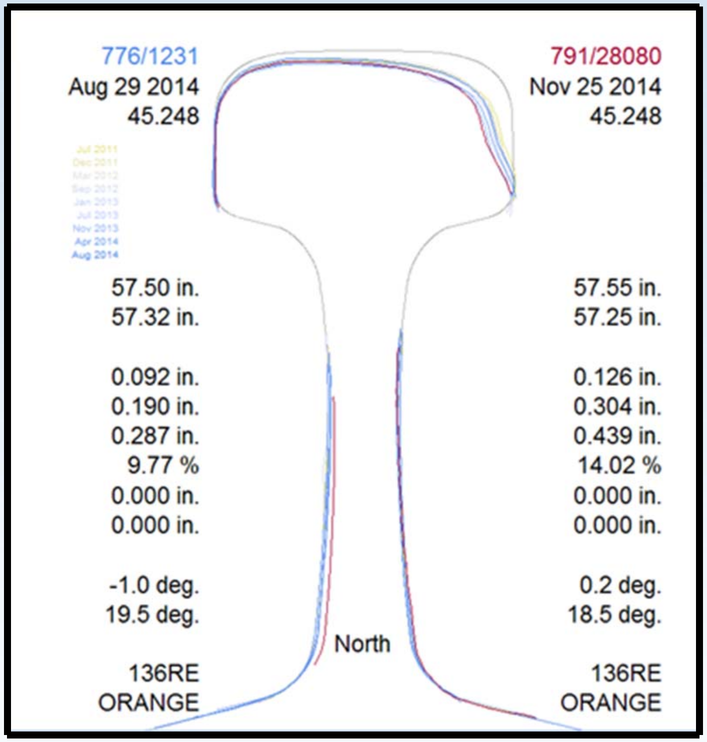
1. Track geometry (TGMV)
2. Rail wear (Laser Profiling)
3. Rail internal defects (Ultrasonic Testing)
4. Ballast profile / section (LIDAR)
5. Vehicle axle and carbody accelerations (Vehicle / Track Interaction)
6. Rail head condition (Eddy Current Testing and machine vision)
7. Tie condition (Machine Vision and Gauge Restraint Measurement)
8. Internal tie condition assessment (Backscatter Radiation)
9. Ballast and subgrade (Ground Penetrating Radar)

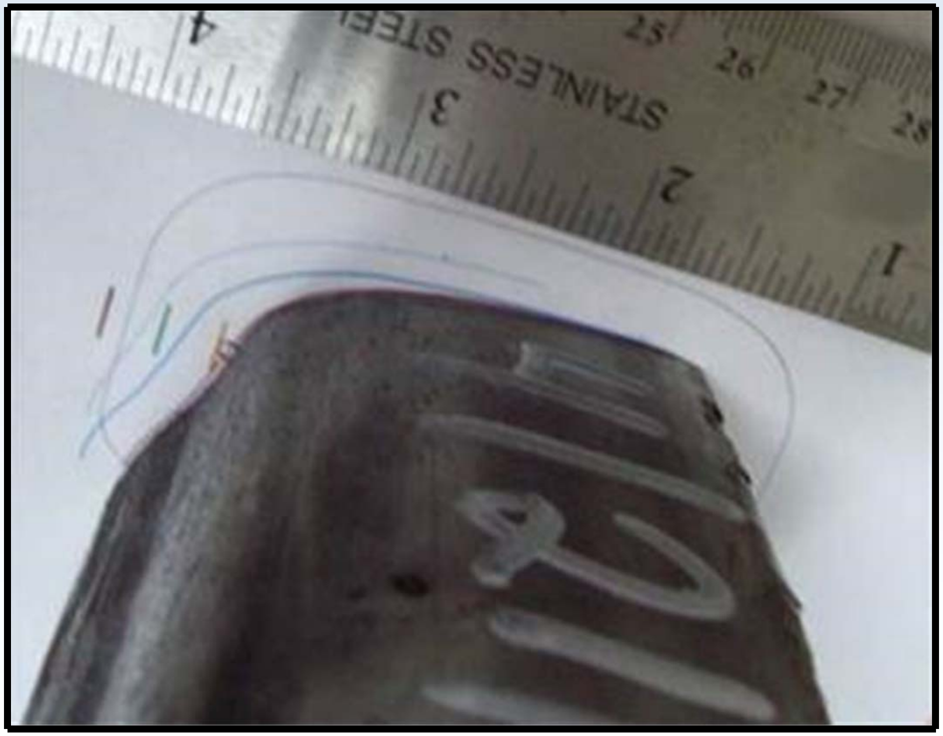
Automated Systems, Concluded

Developing condition grades from assessments

1. Each of the systems on the previous slide provides the means to assess a particular asset or sub-asset within the track.
2. In some cases, the values obtained by direct measurement are sufficient to establish a condition grade.
3. In other cases, the condition or grade is based on a statistical or other analysis of the direct measurements.
4. Two key elements of the FTA State of Good Repair requirements – standards for measuring the condition of a capital asset and reporting changes in condition – are largely met by the technology available through automated inspection systems.
5. This presentation will use rail wear and track geometry to illustrate measurement to determine condition and prioritize investments.

Part 1 – Rail Wear Measurement





Rail Replacement Expenditures

Class I Replacement Rail Expenditures in 2014*

Railroad	Miles of New Rail Laid	Approximate Tonnage (Based on 136 RE)	Average Price / Ton	Expenditure	Theoretical Savings from 5% Improvement
Kansas City Southern	56	6,683	$1,025	$6,850,004	$342,500
Grand Trunk Corporation	176	21,064	$914	$19,252,204	$962,610
BNSF Railway	1,492	178,551	$841	$150,102,126	$7,505,106
Union Pacific Railroad	1,417	169,595	$1,084	$183,840,912	$9,192,046
Soo Line Corporation	367	43,969	$1,019	$44,820,919	$2,241,046
Norfolk Southern	768	91,881	$910	$83,611,464	$4,180,573
CSX Transportation Inc.	636	76,103	$954	$72,602,563	$3,630,128
Totals	4,912	587,845	$954.47	$561,080,192	$28,054,010

*Cost of rail F.O.B. destination. From reports to Surface Transportation Board

Rail Wear Measurement

Asset Replacement and Investment

1. As the example on the prior slide shows, rail is a significant investment for railroads. Similarly, it represents a large investment for transit properties.
2. A 15 mile double track light rail line will require about 6500 tons of rail, for an expenditure of $6,500,000 at $1,000 / ton.
3. The potential for savings in replacement costs large. A hypothetical 5% reduction in the expenditures by the Class I's in 2014 represents a savings of $28,000,000.
4. Ensuring a prudent expenditure of available funds for rail replacement requires an accurate measurement of rail wear.

Laser profiling of rail is widely accepted for determining the amount of wear on the top and sides of the rail head.

Laser Profiling System

Basic System Operation

1. A laser illuminates the rail head, web, and base
2. Camera captures the trace of the laser line on the rail
3. Computer processes the trace to generate a profile
4. The actual profile is compared to the ideal profile
5. The amount of wear around the head of the rail is calculated

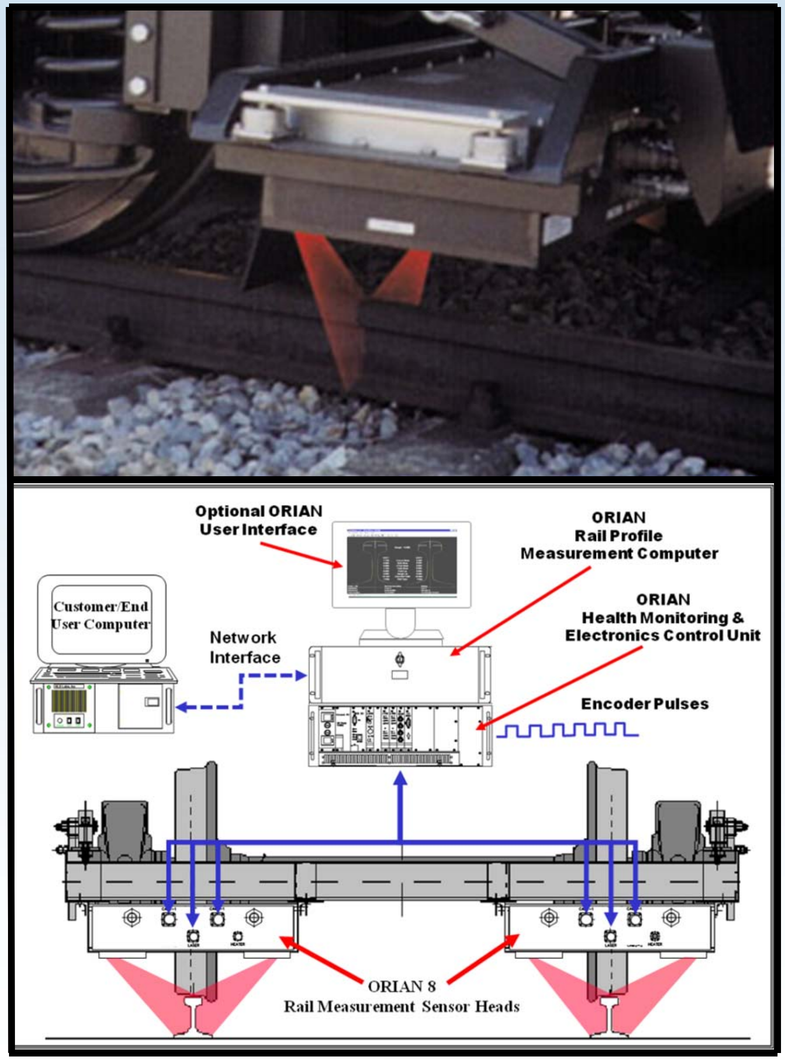


Photo Courtesy of KLD Labs, Inc. Copyright 2015

Wear Limits and Trends

Actual rail profiles are compared to wear limits

1. **The profiles are typically taken at 10-foot intervals and indexed by location.**
2. **The wear measurements are calculated and then compared to threshold ranges, which determine the classification of the rail.**
3. **Up to nine previous measurements may be compared to the current measurement and a trend line is fit to the data.**
4. **Threshold ranges are color coded for rapid identification of potential problem areas.**
5. **Threshold limits may be taken from an existing standard or calculated based on a study of the wheel / rail interface.**

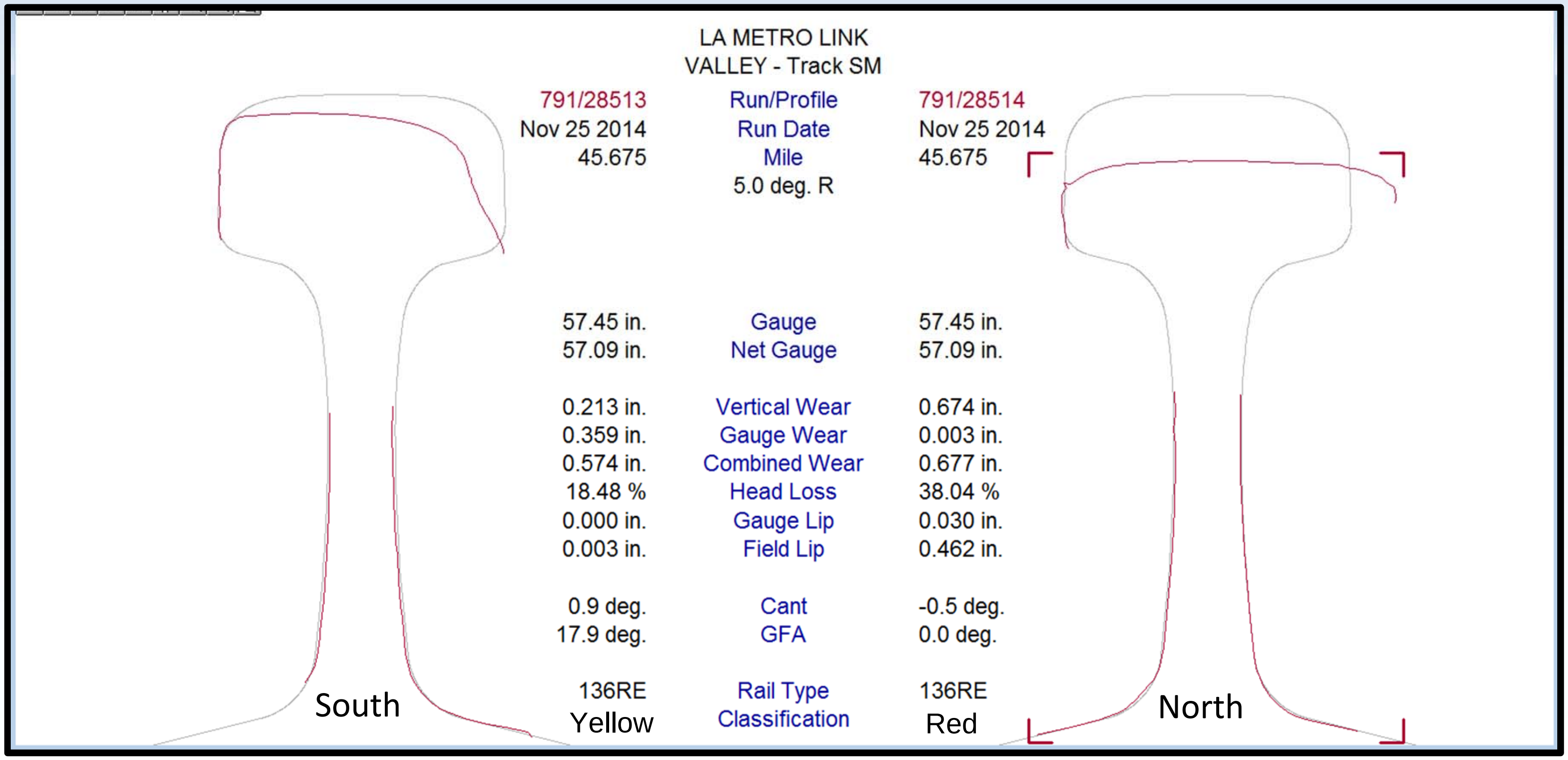
Rail Wear Thresholds

Example of wear ranges for gauge side wear on SCRRA.

Side Wear Limits															
Plan	MNT (Maintenance)						WCH (Watch)			PGM (Program Replacement)			NCL (Near Condemning Limit)		
Grade	1			2			3			4			5		
Color	Green			Blue			Yellow			Orange			Red		
RAIL WEIGHT	Greater than or Equal to	but less than or equal to	Gauge Face Angle (Degrees)	Greater than	but less than or equal to	Gauge Face Angle (Degrees)	Greater than	but less than or equal to	Gauge Face Angle (Degrees)	Greater than	but less than or equal to	Gauge Face Angle (Degrees)	Greater than	Critical Wear Limits	Gauge Face Angle (Degrees)
136 RE	0"	1/8"	Not Used	1/8"	5/16"	Not Used	5/16"	1/2"	Not Used	1/2"	11/16"	Not Used	11/16"	13/16"	Not Used
133 RE	0"	1/8"	Not Used	1/8"	5/16"	Not Used	5/16"	1/2"	Not Used	1/2"	11/16"	Not Used	11/16"	13/16"	Not Used
132 RE	0"	1/8"	Not Used	1/8"	5/16"	Not Used	5/16"	1/2"	Not Used	1/2"	11/16"	Not Used	11/16"	13/16"	Not Used
132 HF	0"	1/8"	Not Used	1/8"	1/4"	Not Used	1/4"	3/8"	Not Used	3/8"	1/2"	Not Used	1/2"	5/8"	Not Used
119 RE	0"	1/8"	Not Used	1/8"	1/4"	Not Used	1/4"	3/8"	Not Used	3/8"	1/2"	Not Used	1/2"	5/8"	Not Used
115 RE	0"	1/8"	Not Used	1/8"	1/4"	Not Used	1/4"	3/8"	Not Used	3/8"	1/2"	Not Used	1/2"	5/8"	Not Used
113 HF	0"	1/8"	Not Used	1/8"	1/4"	Not Used	1/4"	3/8"	Not Used	3/8"	1/2"	Not Used	1/2"	5/8"	Not Used

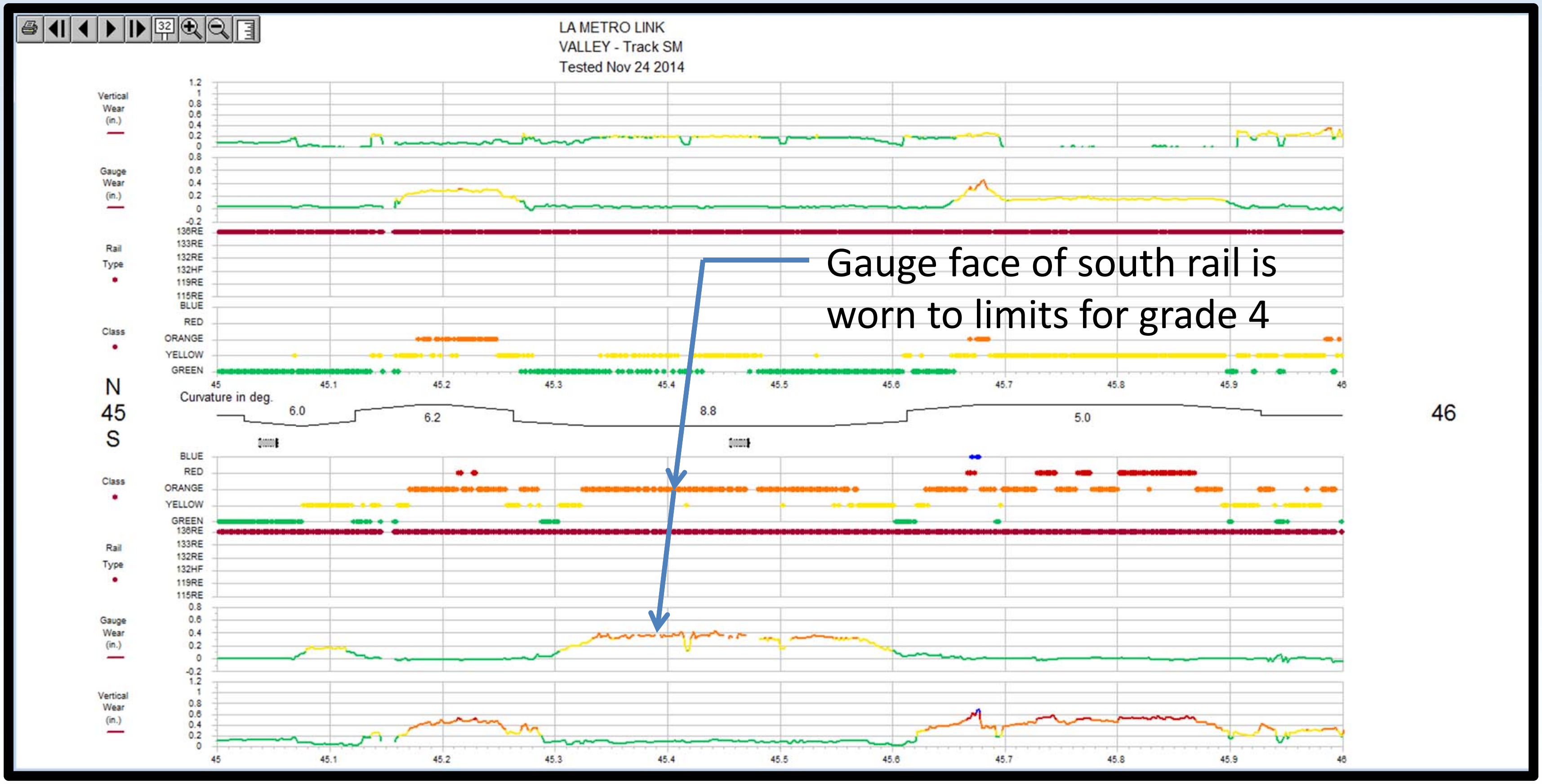
Rail Profiles and Wear Calculations

Example of Profile



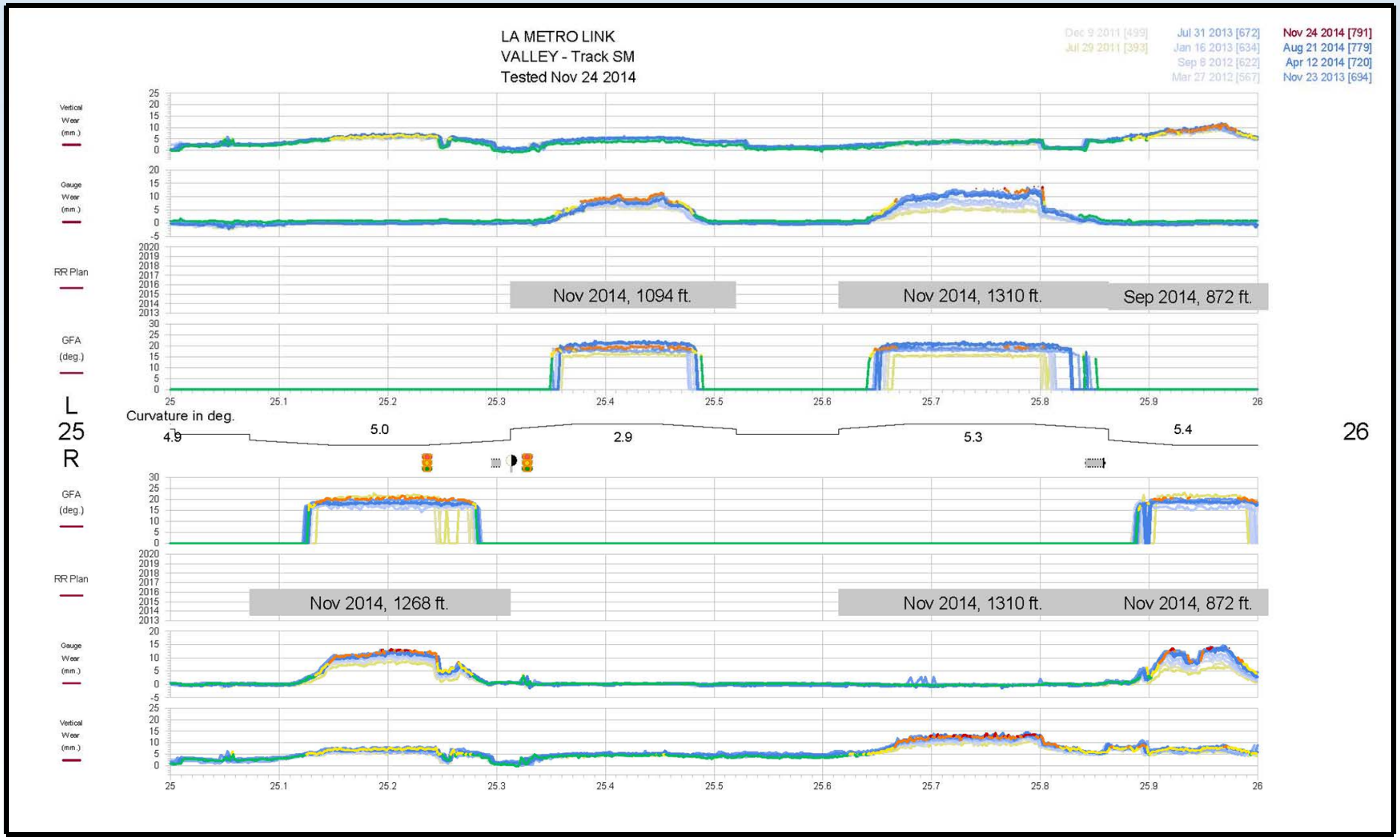
Graphical Report of Rail Wear

Assignment of colors to wear ranges permits rapid analysis of conditions along an alignment



Rail Replacement Projection

Projection uses multiple runs to calculate date wear limit will be reached.



Part 2 – Assessment of Track Geometry

Developing Methods for Analyzing Track Geometry

Like rail measurement, track geometry may also be expressed in terms of a grade.

1. **Track geometry measurements, however, are often based on a pass / fail measurement.**
2. **Trends are not readily discernible and comparison of the same or different segments of track is difficult, particularly over time.**
3. **Like rail profile measurement, it is desirable to have a means of quantifying and predicting changes over time and before a reactive response is required.**
4. **Studying changes in track geometry over time will provide the foundation for building a predictive model.**

FRA Safety Standards

Code of Federal Regulations (49 CFR Part 213)

1. The FRA Track Safety Standards set limits within which operations are considered safe.
2. Track measurements falling outside of these limits represent a regulatory violation.
3. FRA track safety standards are not a ***maintenance standard***.
4. At Metrolink, past condition ratings relied on subjective assessments in the absence of a systematic methodology.
5. In rail profiling the measurements of rail wear give results that can be directly equated to a condition index.
6. For track geometry, options are available for establishing condition grades based on fixed intervals, variable intervals or statistical measures.

Fixed Interval Approach

Stepped Interval Grading

1. This is a sample of an approach that assumes a regularly stepped interval to record a change in condition.
2. If gauge restraint measuring is used, changes from static gauge measurement could be used as flag.

Wide Gauge Class 4 and 5 Track 49 CFR 213.53 Maximum 57.5 Inches Graded in 1/4 Inch Increments			
Measured Gauge (Inches)	Cumulative Change	Color Code	Condition Code
56.50			
	0.25	Green	1
56.75			
	0.50	Blue	2
57.00			
	0.75	Yellow	3
57.25			
	1.00	Orange	4
57.50			
	1.25	Red	5
57.75			

Variable Interval Approach

Intervals may be varied to give greater weight to one set of conditions over another.

Rating	Comparison	P_1	P_2	$P_2 - P_1$	Color	
1	$P_1 >$ Gauge $<= P_2$	56.50	57.00	1/2"	Green	Wide
2	$P_1 >$ Gauge $<= P_2$	57.00	57.25	1/4"	Blue	
3	$P_1 >$ Gauge $<= P_2$	57.25	57.38	1/8"	Yellow	
4	$P_1 >$ Gauge $<= P_2$	57.38	57.50	1/8"	Orange	
5	Gauge $> P_2$	57.50			Red	
3	$P_1 >=$ Gauge $< P_2$	56.25	56.50	1/4"	Yellow	Narrow
4	$P_1 >=$ Gauge $< P_2$	56.00	56.25	1/4"	Orange	
5	Gauge $< P_2$	56.00			Red	

Simple Statistical Methods

Standard deviation of a set of measurements may be used as a measure of track quality

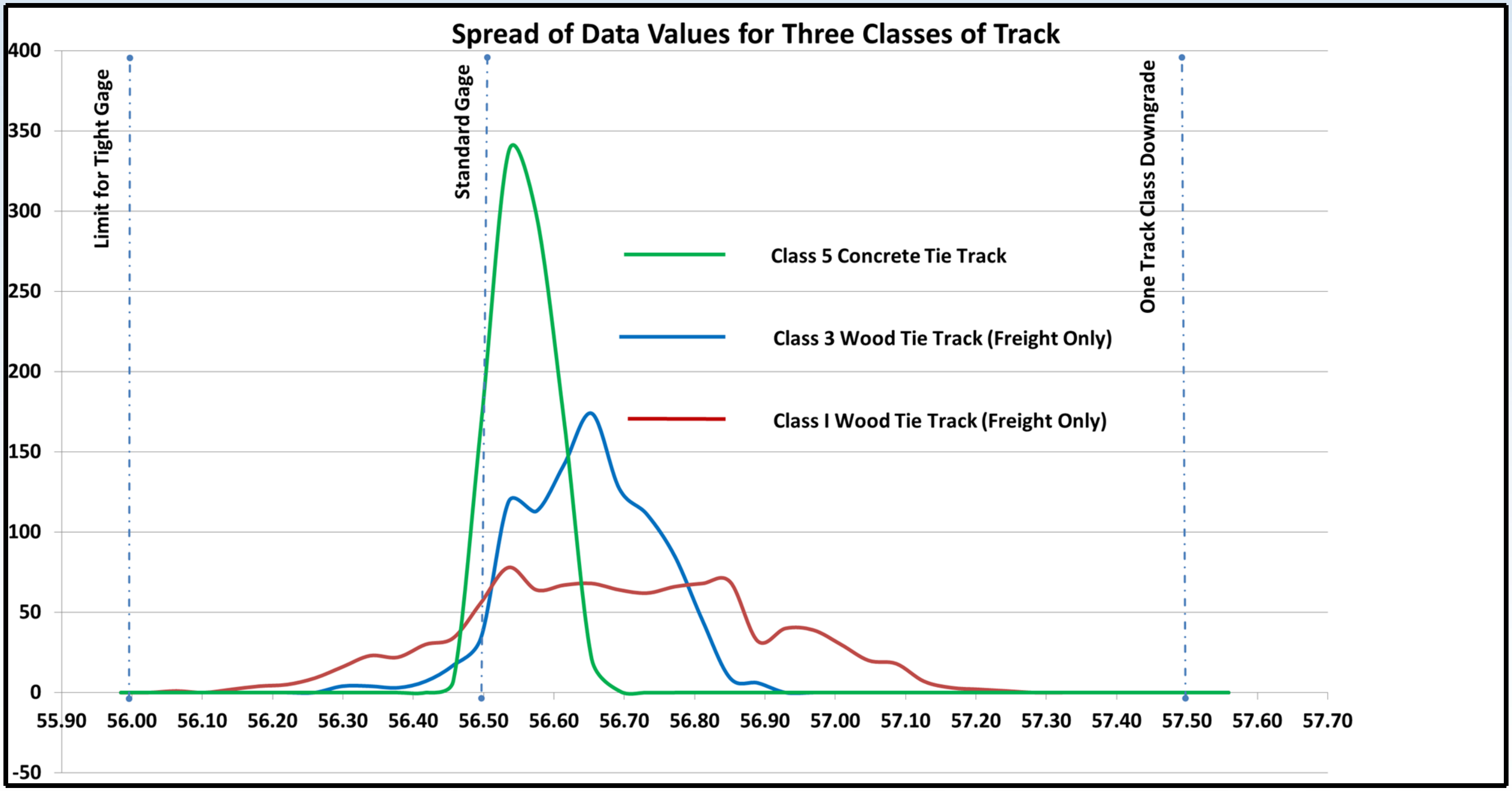
1. Standard Deviation is a statistical measure that quantifies the amount of variation or spread of a set of data values.
2. A high standard deviation indicates that the data varies widely from the average value, while a low standard deviation indicates that the values of the data are closely spaced.

Example:

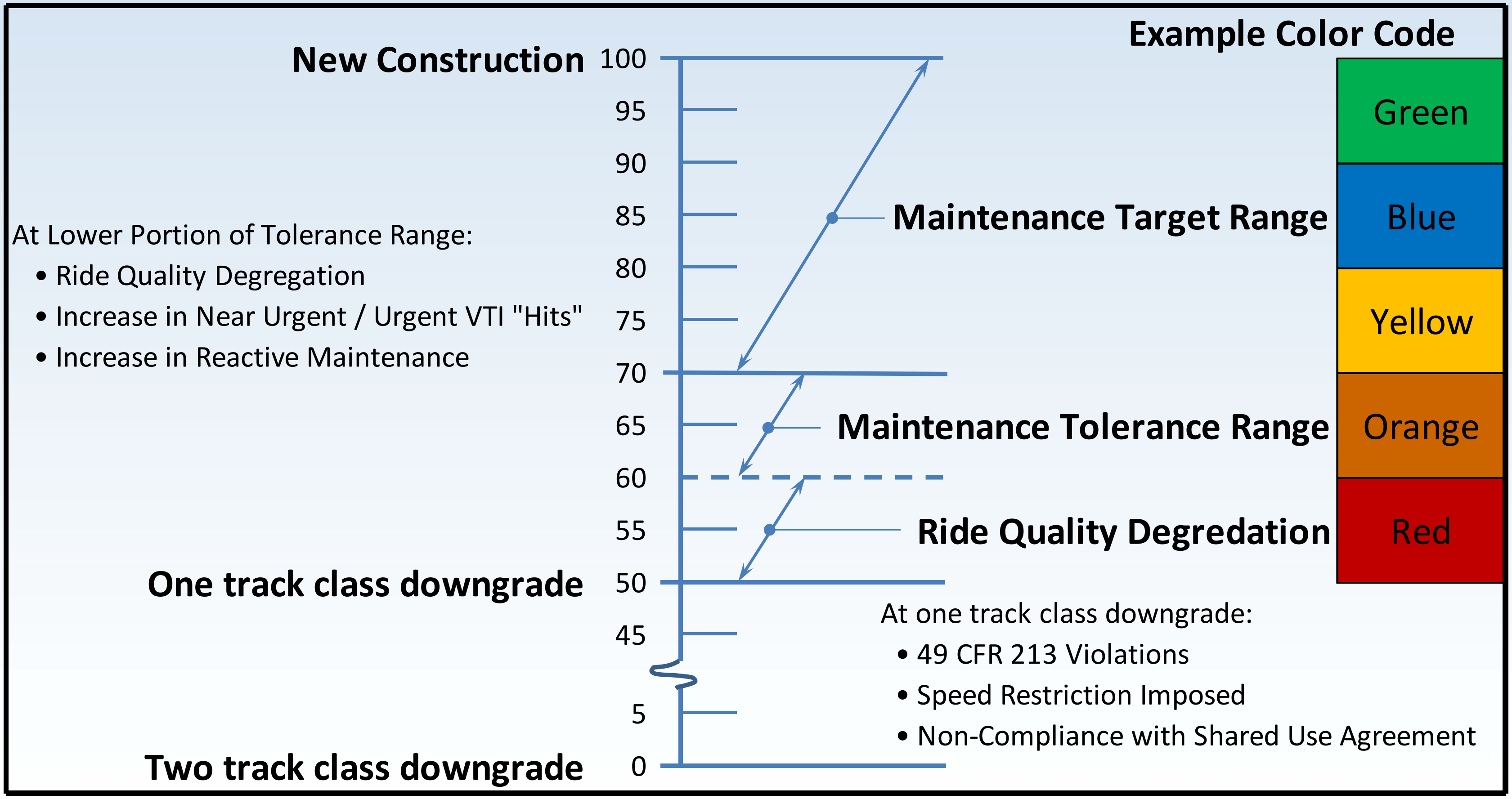
1. The gauge measurements on a segment of concrete tie track will typically show a very narrow distribution.
2. Lower class track will tend to show broader distribution.
3. The spread of the values of the track geometry measurements in a segment of track will tend to increase as the track degrades.

Spread of Data for Three Classes of Track

Example: Gauge Restraint Loaded Gauge



Equating State of Good Repair to FRA Track Safety Standards



Quality Index Development

The development of a relationship between the measured track parameters, the standard deviation of a set of measurements, and the quality index is the next step.

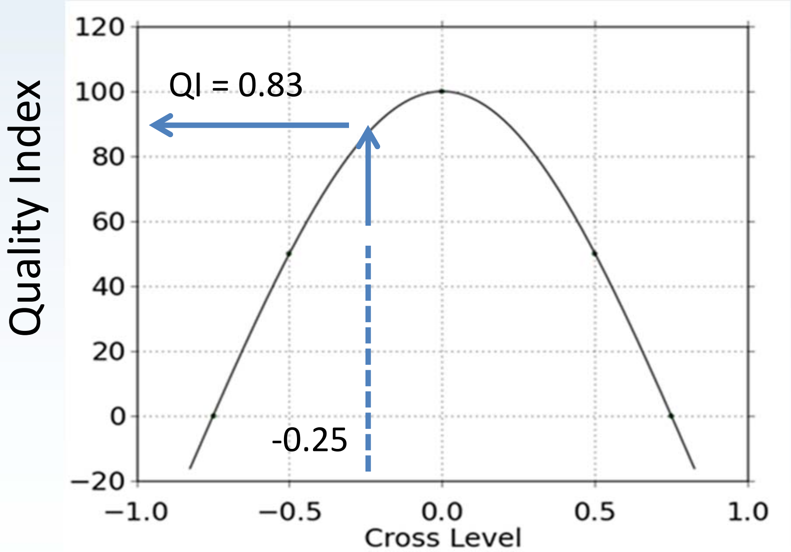
Track degradation models are complex and involve many factors. Therefore, we propose a simplified approach:

1. **Select a mathematical function that correlates the change in a track parameter to a quality index.**
2. **In the example case on the next slide case, we selected a parabola was a reasonable approach to quantifying the change in in track geometry to our quality index.**
3. **The parabola is fit to a set of values where a Quality Index of 100 represents the perfect condition, and a Quality Index of 50 represents a one track class downgrade.**

Calculating the Quality Index

Standard deviation or percentile as an indicator of track quality

1. For a set of measured values from a given track geometry parameter the extreme values provide a leading indicator of the condition.
2. Assuming a Normal Distribution, the average of the measured values plus or minus three standard deviations (3σ), will include 99.7% of values included in a segment. Alternatively, the 99th percentile may be used. Both indicate the extremes.
3. For the segment of tangent track used for the example at right, we obtained the following values:
   Average = -0.286 in.
   Standard Deviation = 0.0835 in.
   Average plus 3σ = -0.035 in.
   Average minus 3σ = -0.250 in.
   Quality Index = 0.83



Review of Key Points

1. Identify Asset Classes, assets, and sub-assets
2. Reconcile regulatory and accounting requirements
3. Establish threshold wear or degradation limits
4. Establish condition grades corresponding to limits
5. Select measurement and condition assessment systems
6. Segment the track by length or characteristic
7. Calculate quality or grade indices for each segment
8. Let computer programs perform the number crunching
9. Focus on planning and efficiency