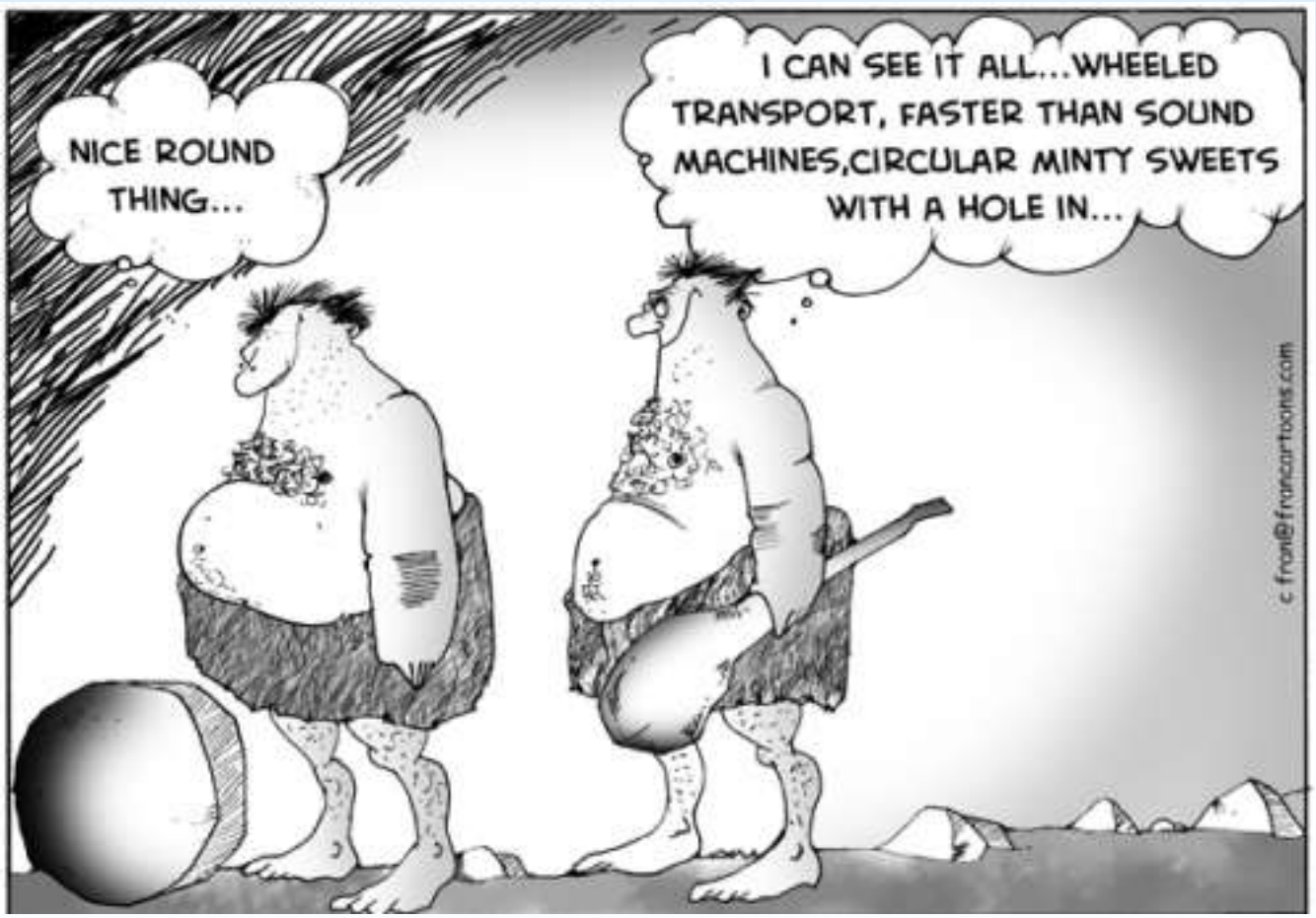
A Better Understanding of Modern Rail and Wheel Inspection on North American Railways

The question is not what you look at, but what you see.

Henry David Thoreau


NICE ROUND THING...
I CAN SEE IT ALL...WHEELED TRANSPORT, FASTER THAN SOUND MACHINES,CIRCULAR MINTY SWEETS WITH A HOLE IN...
c fran@francartoons.com

Why improve Wheel and Rail Inspection?

1. Increase critical defect detection.
2. Improve data collection and accuracy.
3. Reduce subjectivity in data.
4. Improve work efficiencies with better planning tools provided by trended data.
5. Drive down costs through improved maintenance procedures.
6. Prevent derailments.
7. Increase Safety.

Man is driven to improve.

"No matter how good you get you can always get better, and that's the exciting part."
— Tiger Woods

Wheel Inspection Tools

The manual way it's done now.
Eyeball it, then measure it.

Go or No-Go

Resolution = 1/16"

Better Idea!

- Collect the wheel Profile & Measure it!

“Old School” Method of Wheel Profiling

Using a carpenters tool, the profile was collected then transcribed to a paper.

A Better Idea on a Better Idea

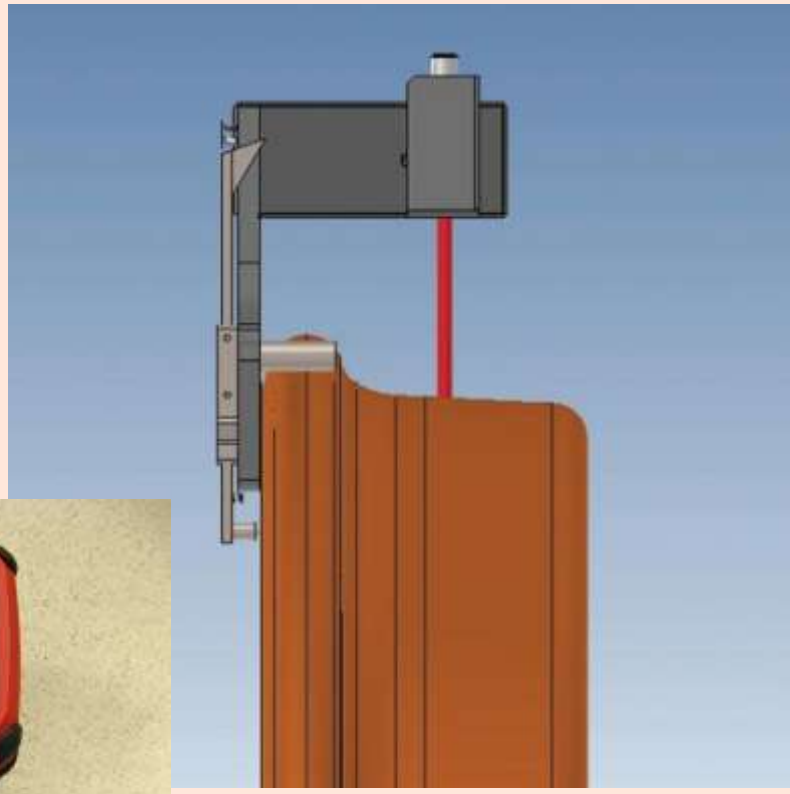
BeenaVision

Non-Contact Laser Based Wheel Profile Devices –

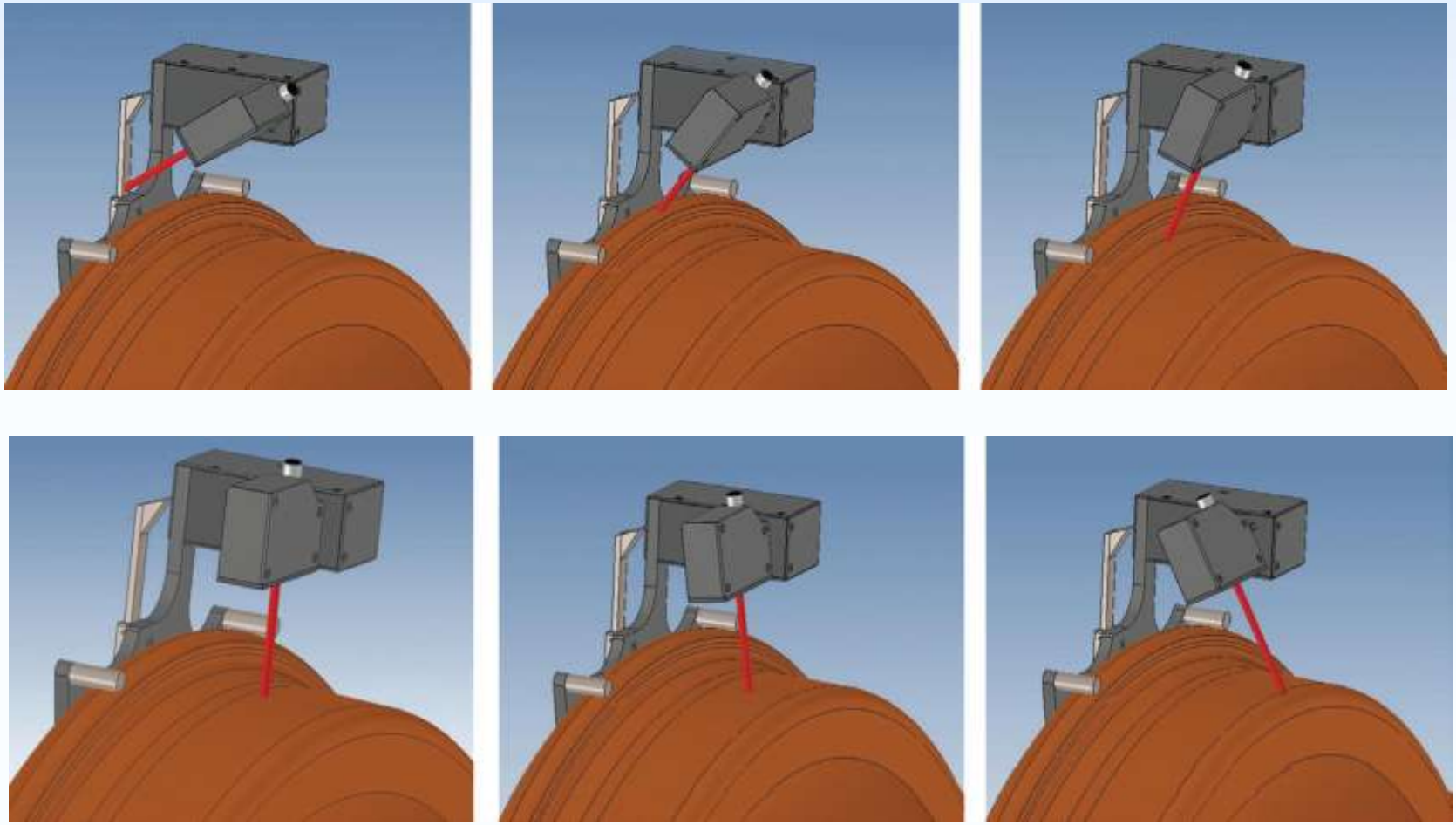
Handheld

Automated

Handheld Wheel Profile Device
Non-Contact Laser



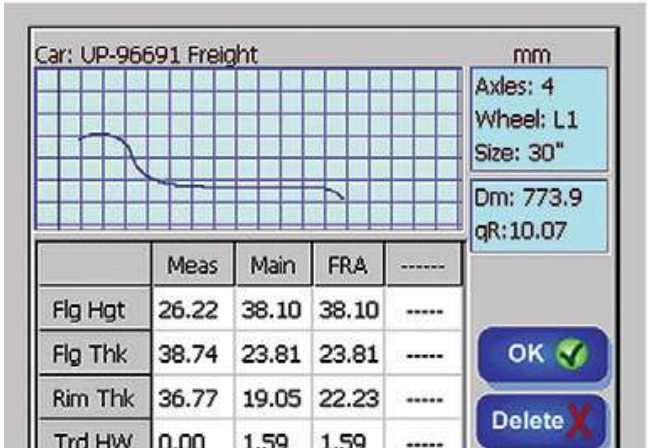
Handheld Wheel Profile Device
Non-Contact Laser Type



Handheld Wheel Profile Device
Non-Contact Laser Type

Beena Vision

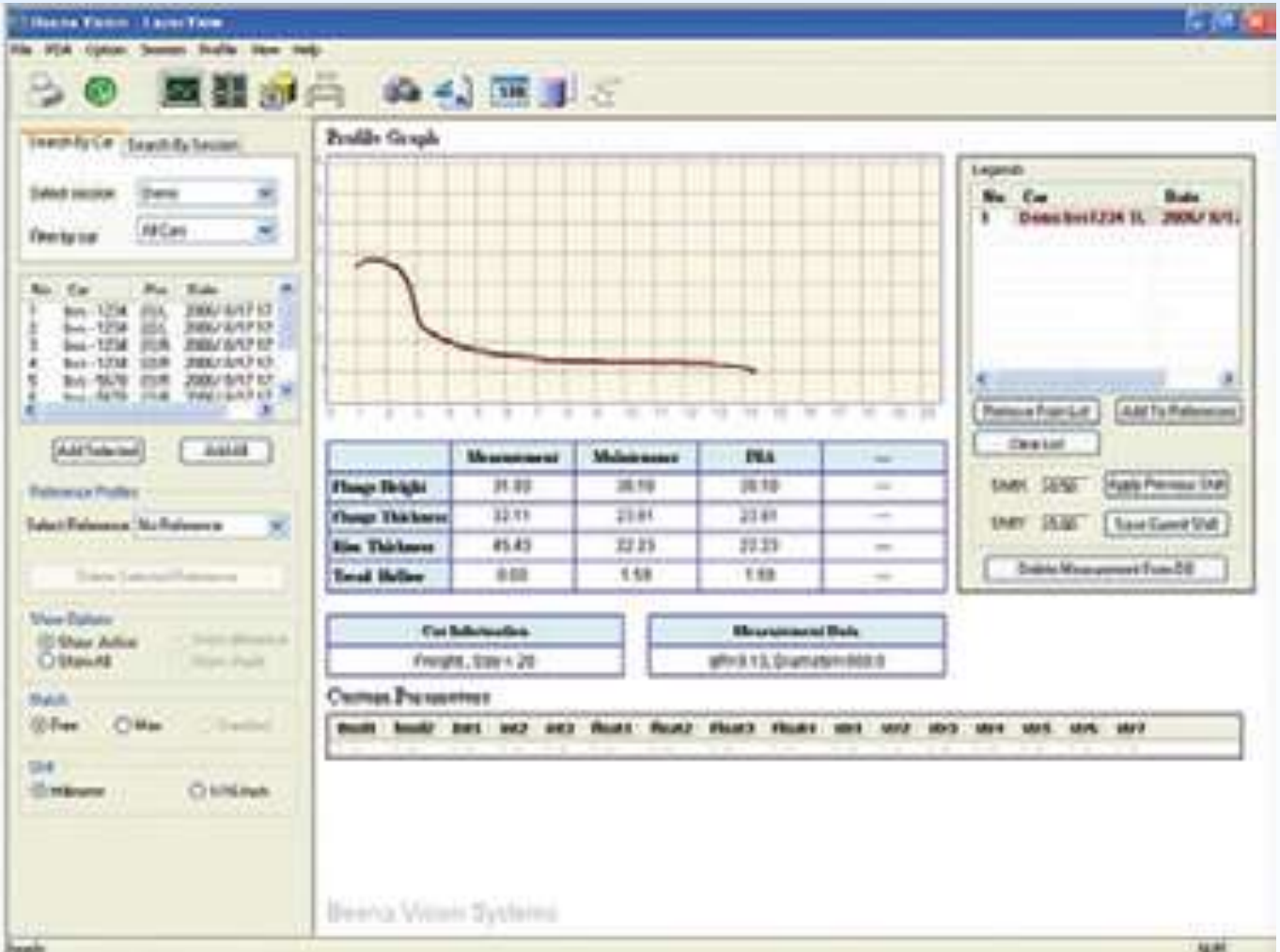
Hand Held Computer Screens



Hand Held screens provide setup, organization and feedback for operations

Handheld Wheel Profile Device
Non-Contact Laser Type

Data can be downloaded to Desktop Software

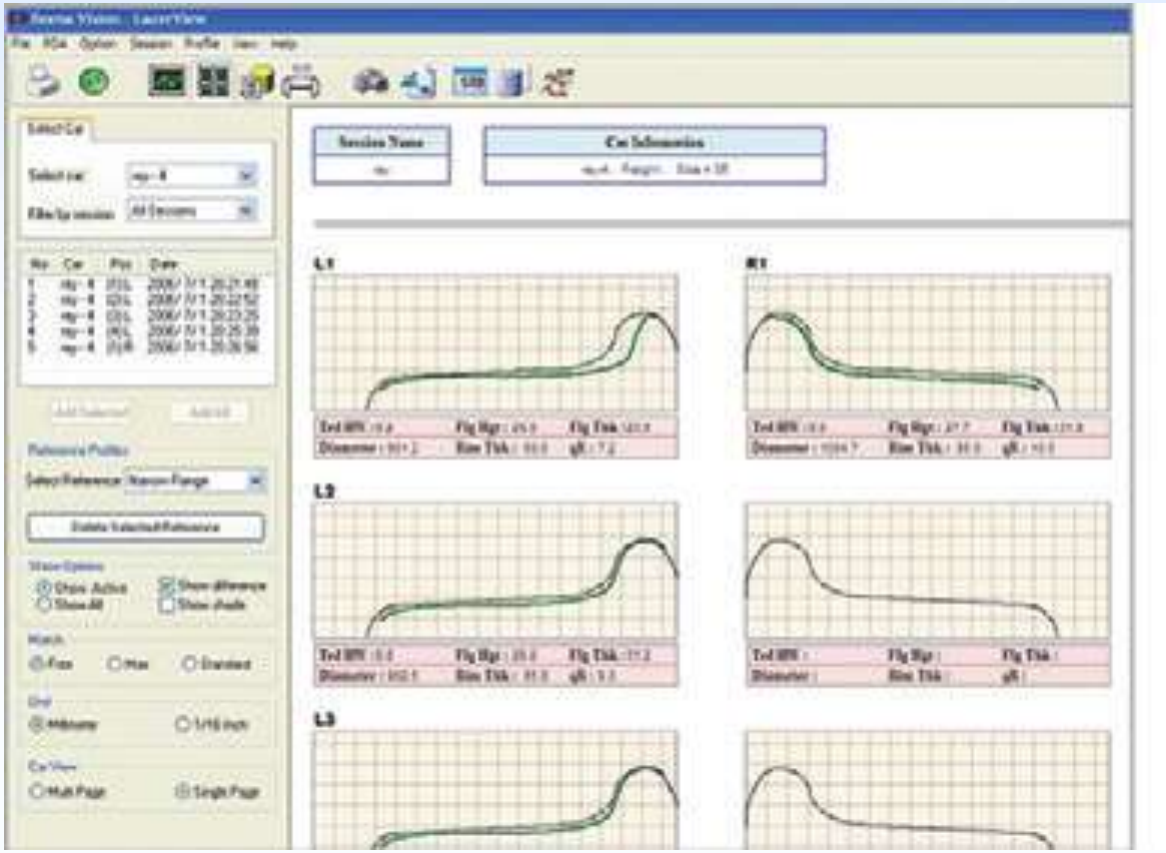


The profiles can be uploaded to the Desktop software, and then displayed with additional detail. Profiles can be overlaid to display wear.

Handheld Wheel Profile Device
Non-Contact Laser Type

BeenaVision

Desktop Software



The Desktop software provides database interface and reporting.
In this report the "Truck View" displays the profiles and their Relationship to each other.
It provides the ability to display multiple profiles with overlay, and overlay of standard profiles For comparison purposes.

Handheld Devices

- Handheld Wheel Profile Measurement
  - Advantages
    - Lower Cost than in-track systems
    - Increased accuracy compared to gage measurement
    - Database integration provides historical information with data trending capabilities
  - Disadvantages
    - More labor intensive than automated in-track systems.

The Best Idea Yet!

Automated-in-Track

Laser Based

Wheel Profile Measurement

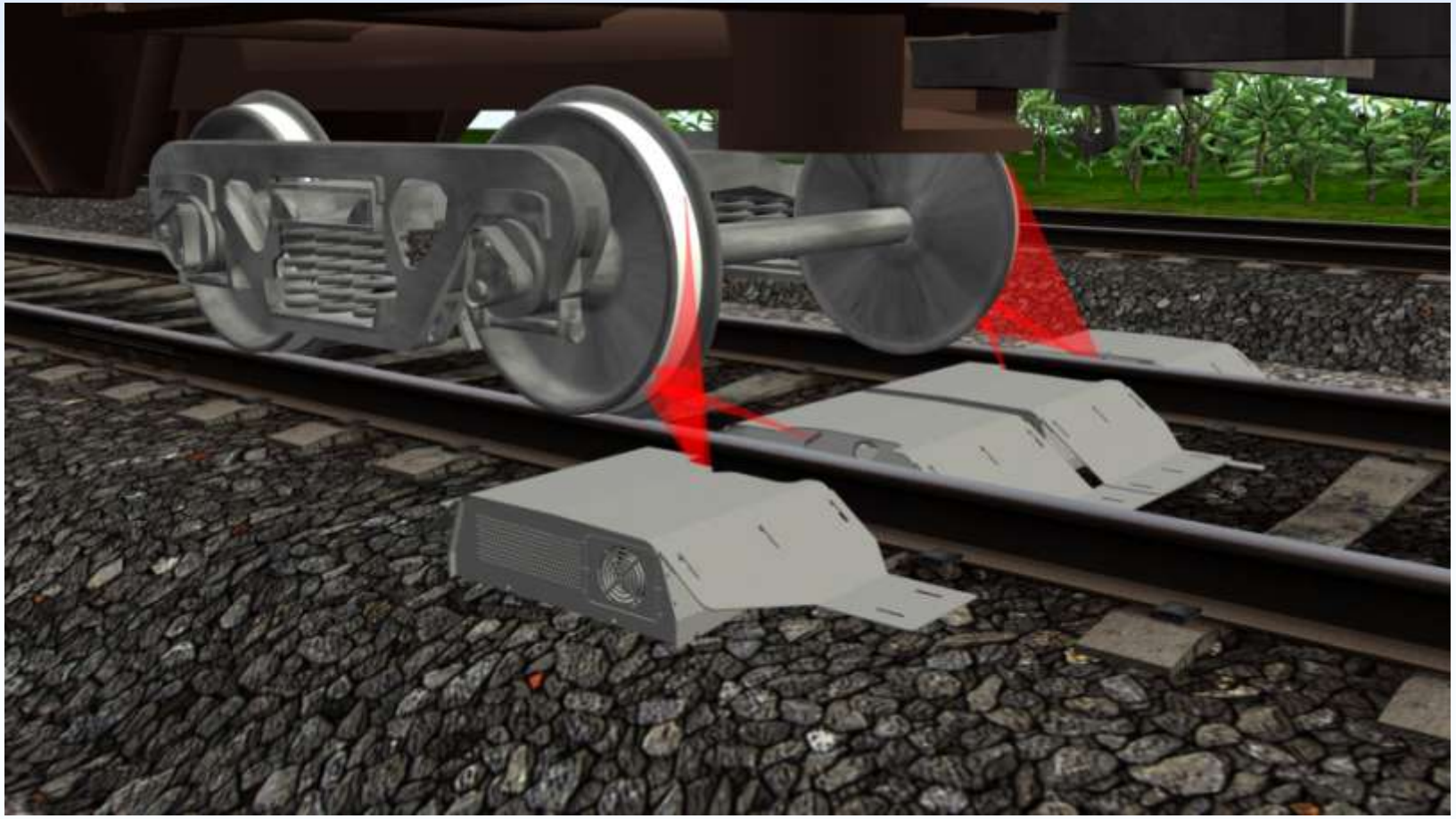
BeenaVision

In Track - Automated

- Laser Profile Measurement of Wheels

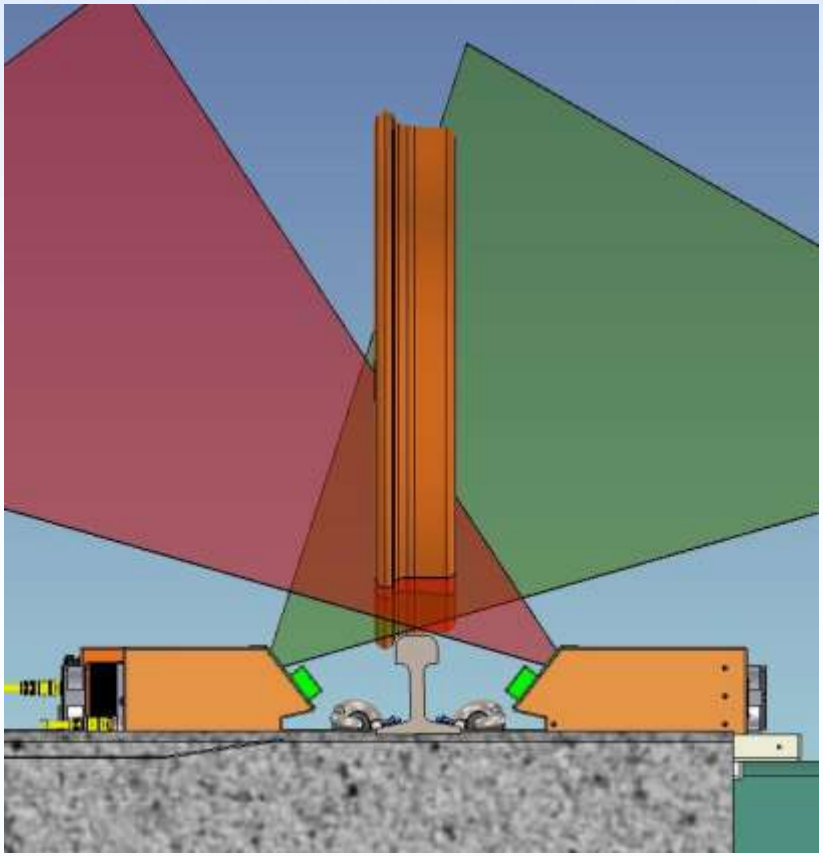
Laser Based

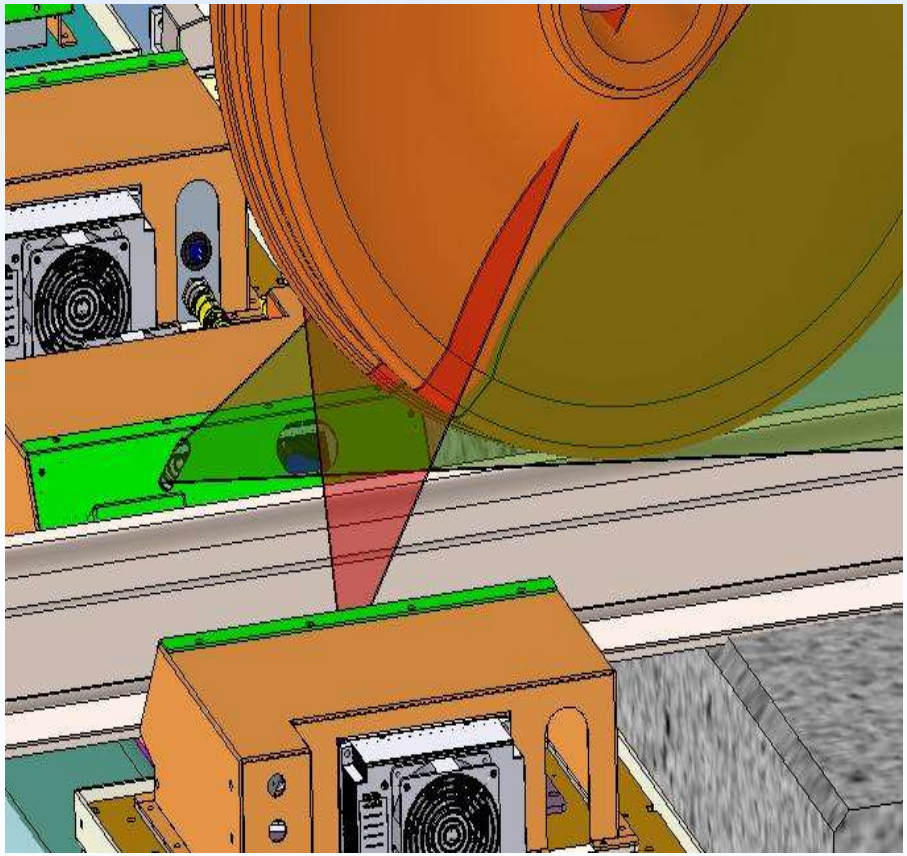
BeenaVision



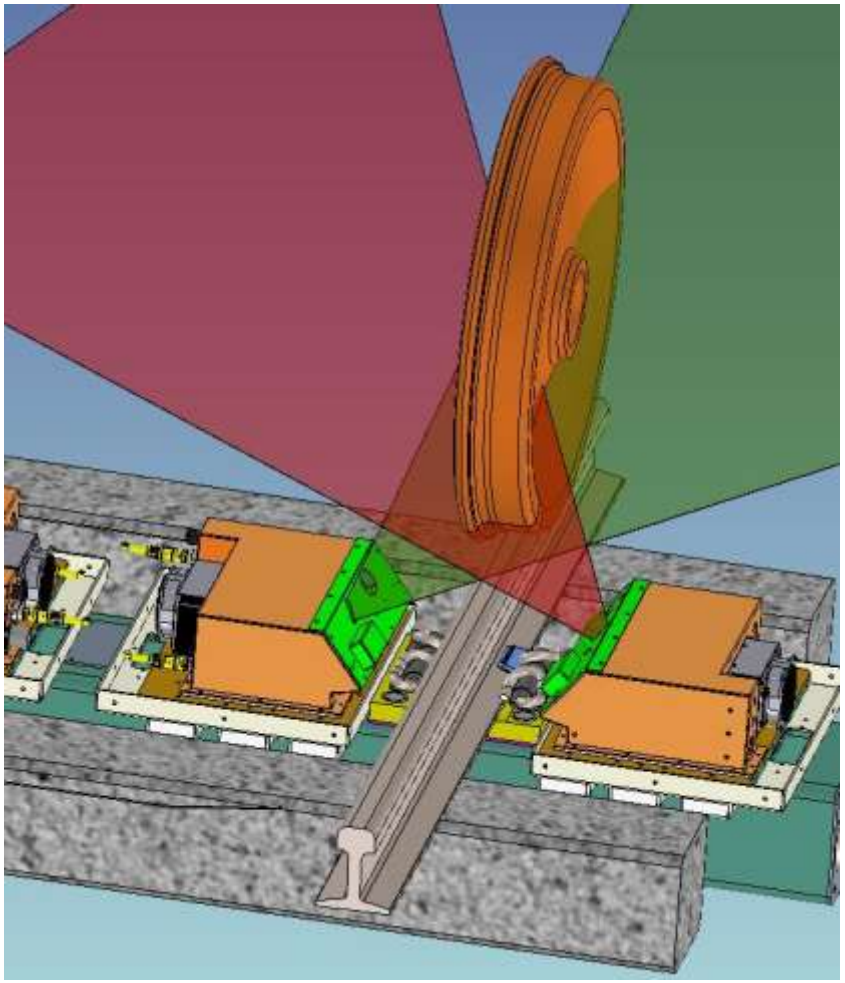
How it works.

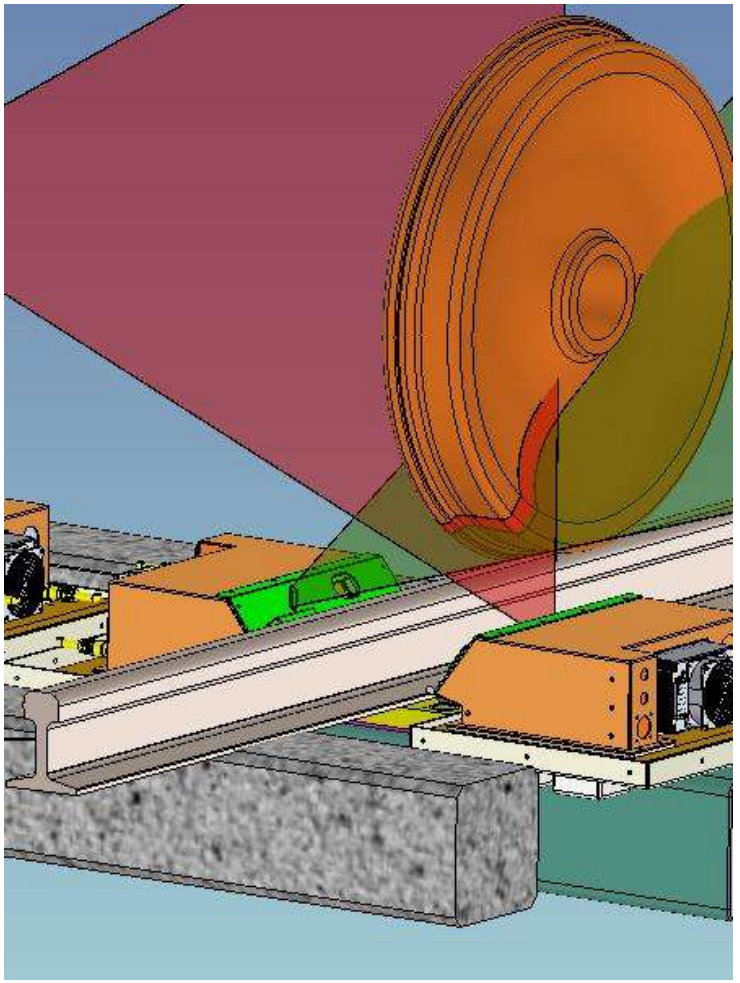
Laser Profiles





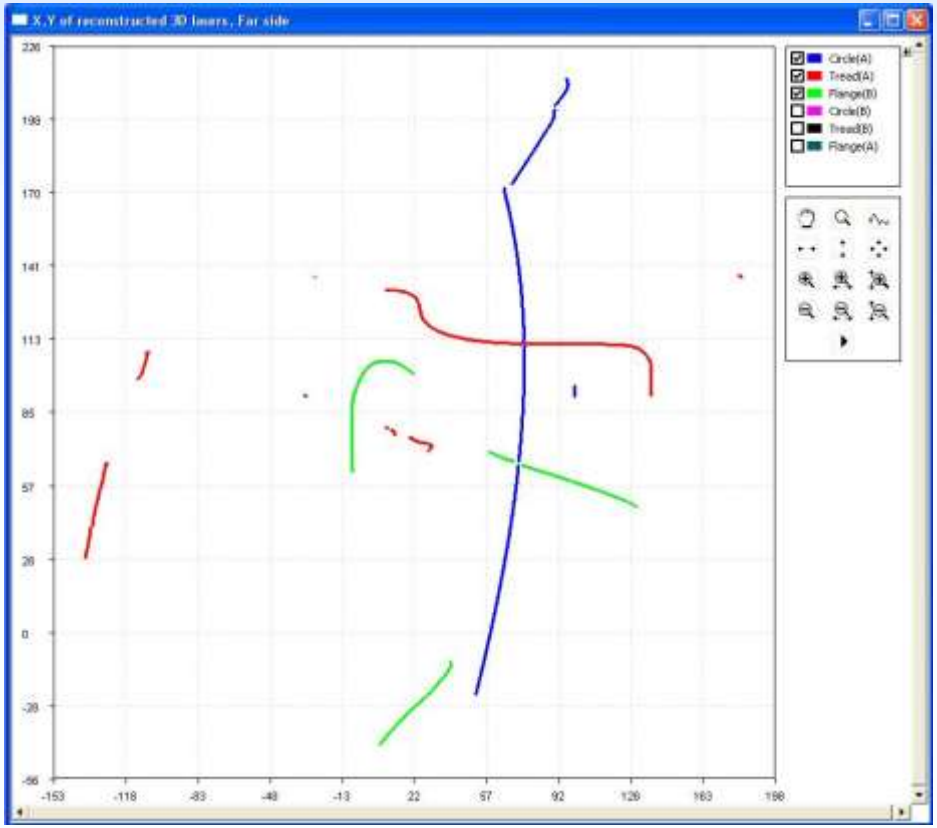
Wheel Profile Measurement Principle

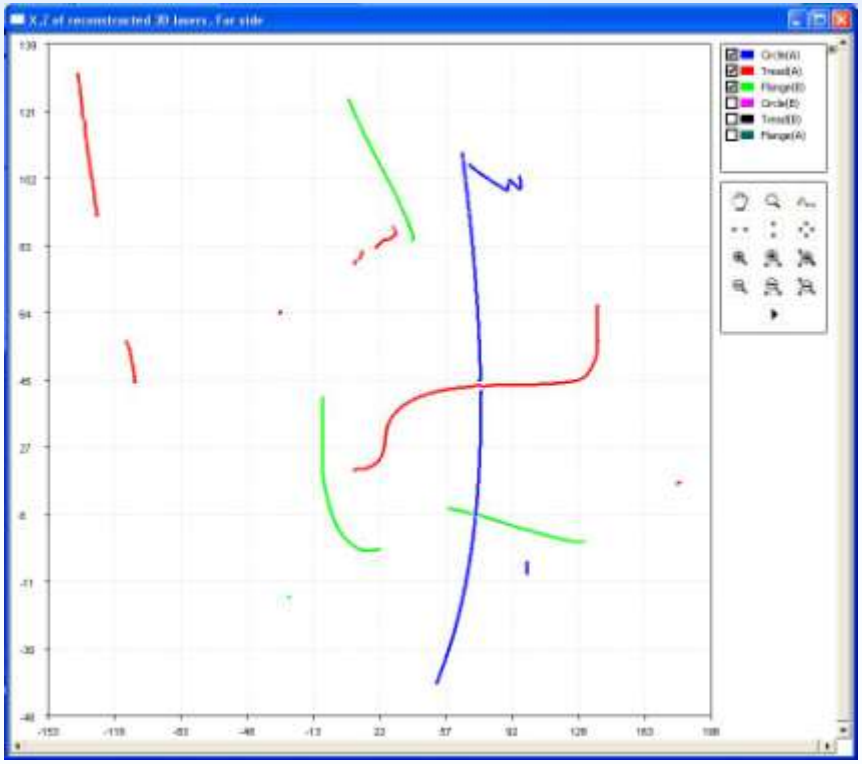




Raw Image Quality

Raw Laser Data





Parameter Measurement

Wheel Profile Measurement

- Standard Measurements
  - Flange Height
  - Flange Thickness
  - Flange Slope
  - Tread Hollow
  - Rim Thickness
- Extensions
  - Back-to-Back
  - Wheel Type (straight plate, etc.)
  - Tracking Position

These systems are not fragile, and work in all environments.

- Saudi Arabia (Dry and Hot)

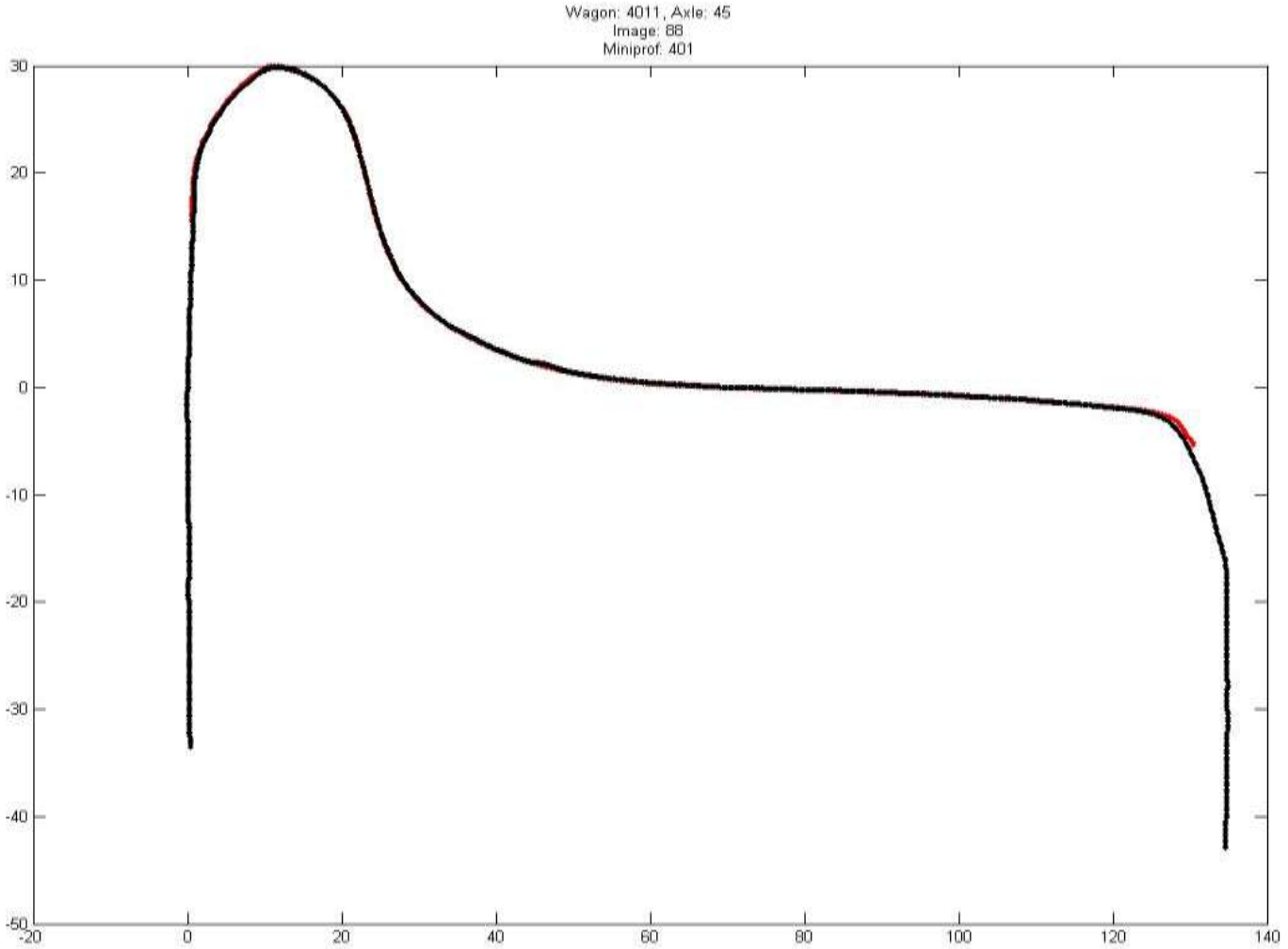
- South America (Hot and Humid)

- Finland (Extreme Cold, Snow, Ice)

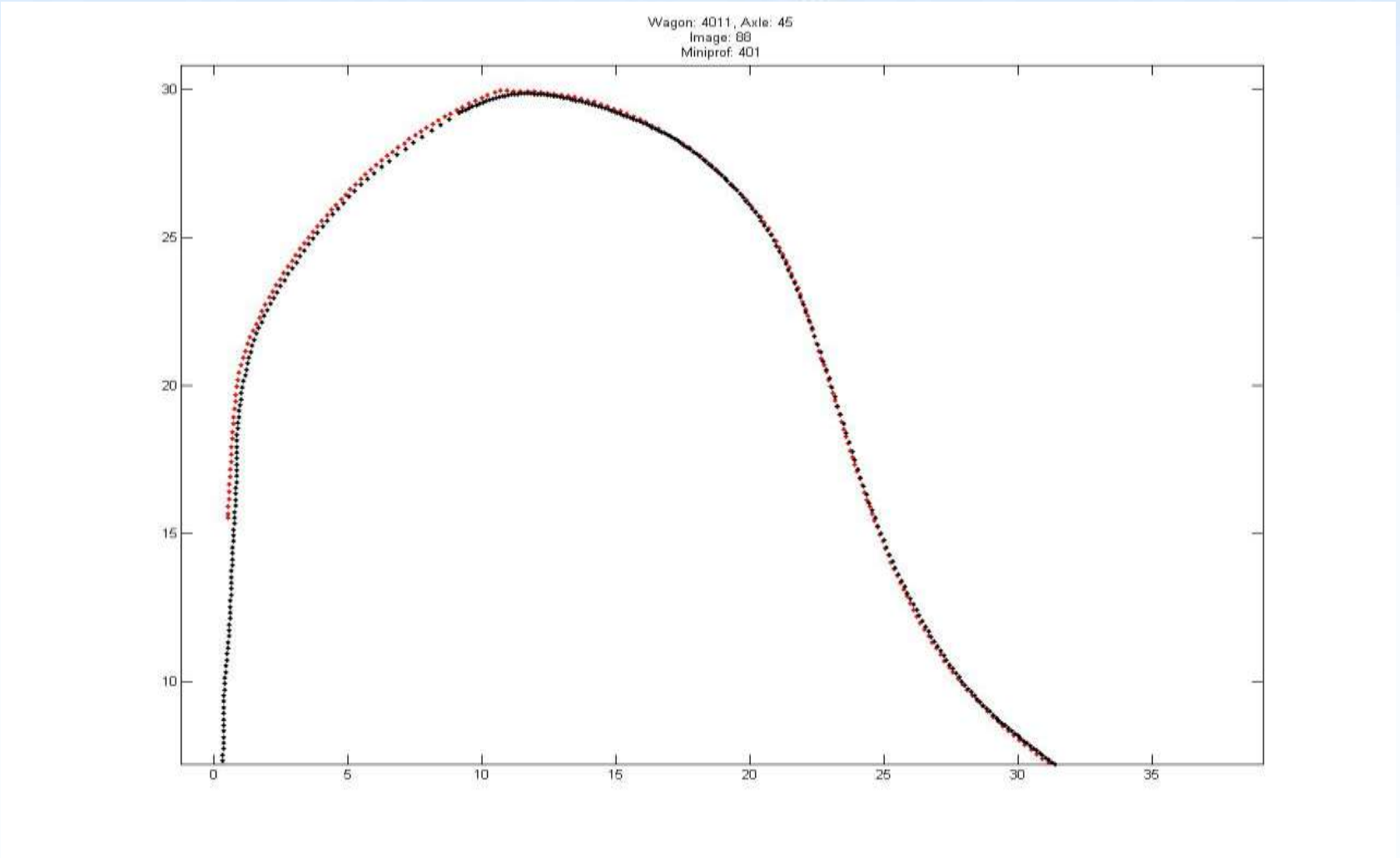
Shutters

Air Purge System

Accuracy


Wagon: 4011, Axle: 45
Image: 88
Miniprof: 401
30
20
10
0
-10
-20
-30
-40
-50
-20
0
20
40
60
80
100
120
140

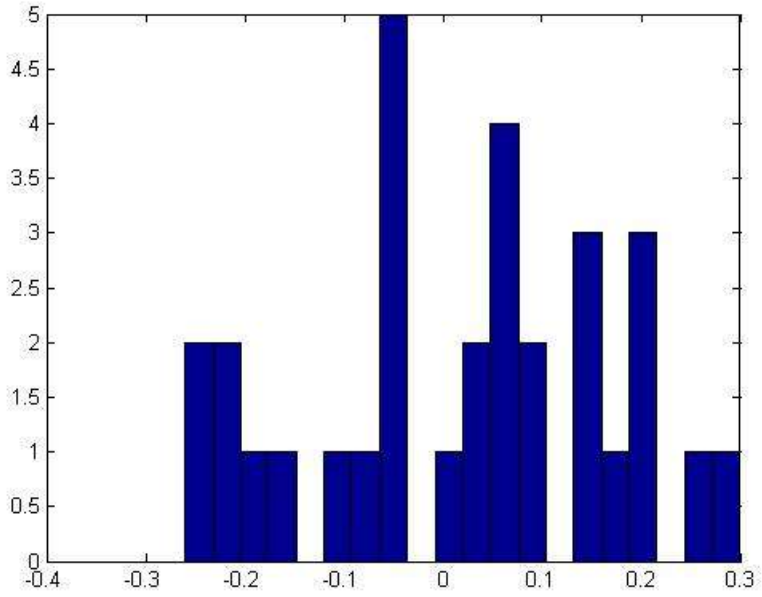
Flange - Top Area



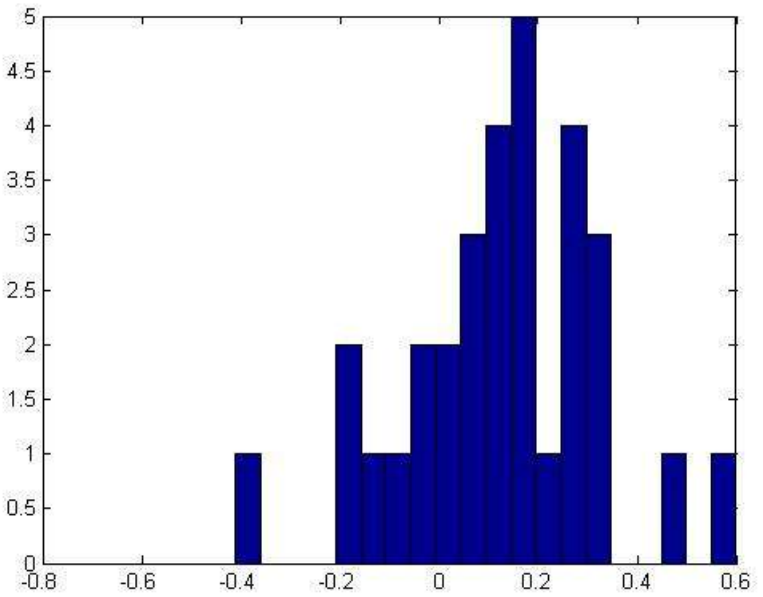
Typical Error Distribution

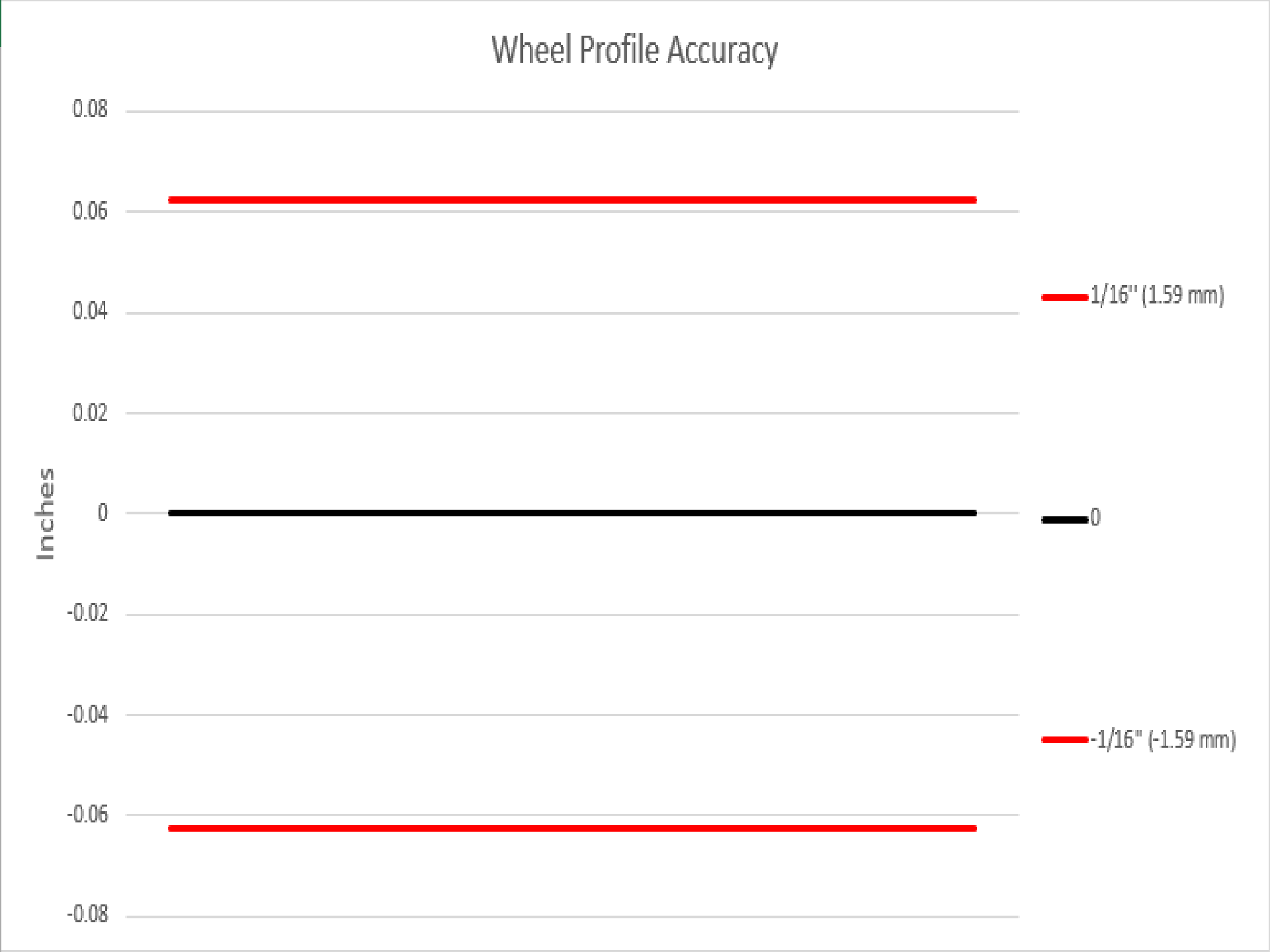
- Performed for 30 wheels at 130km/h speed

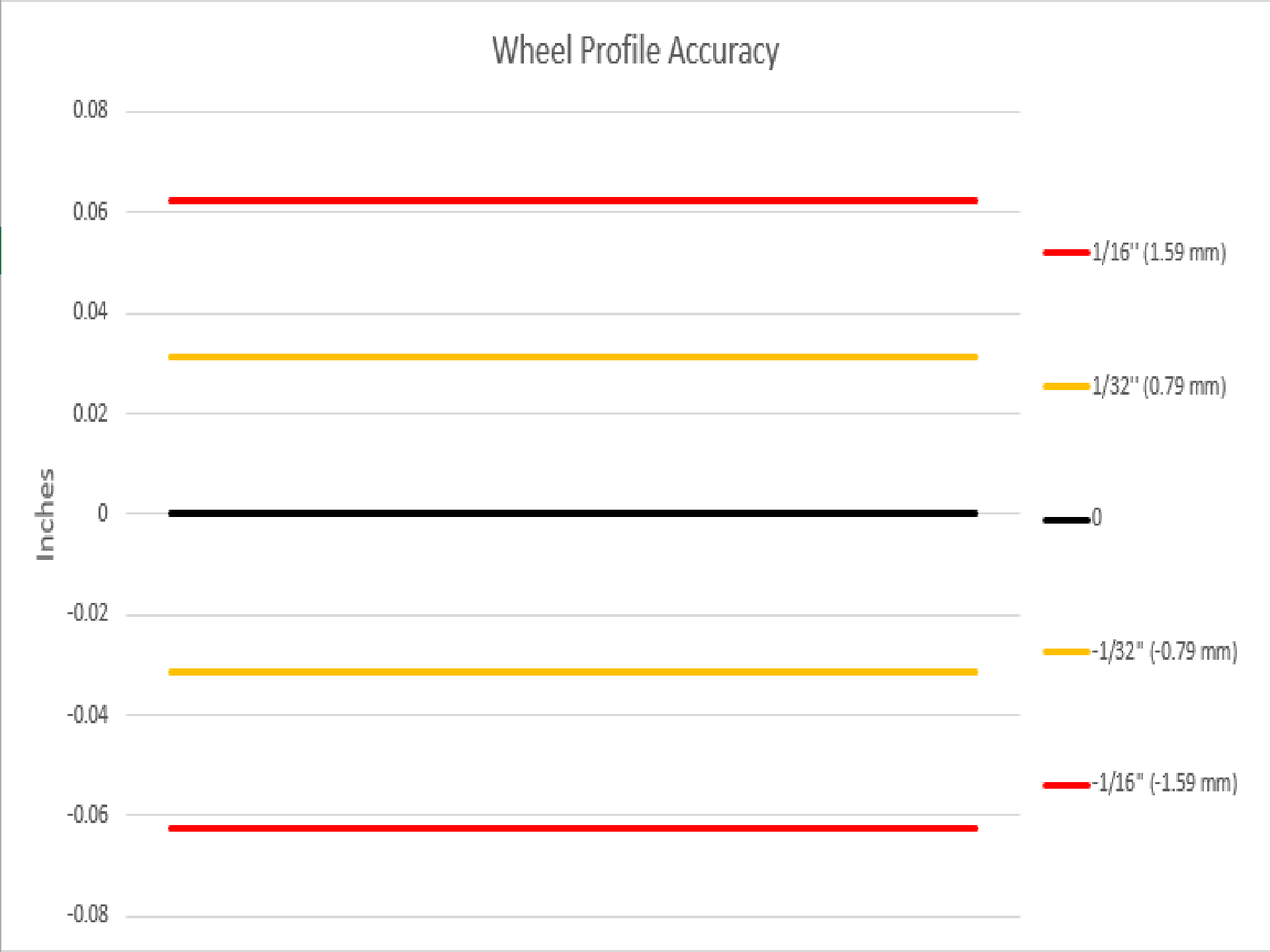
Flange Height



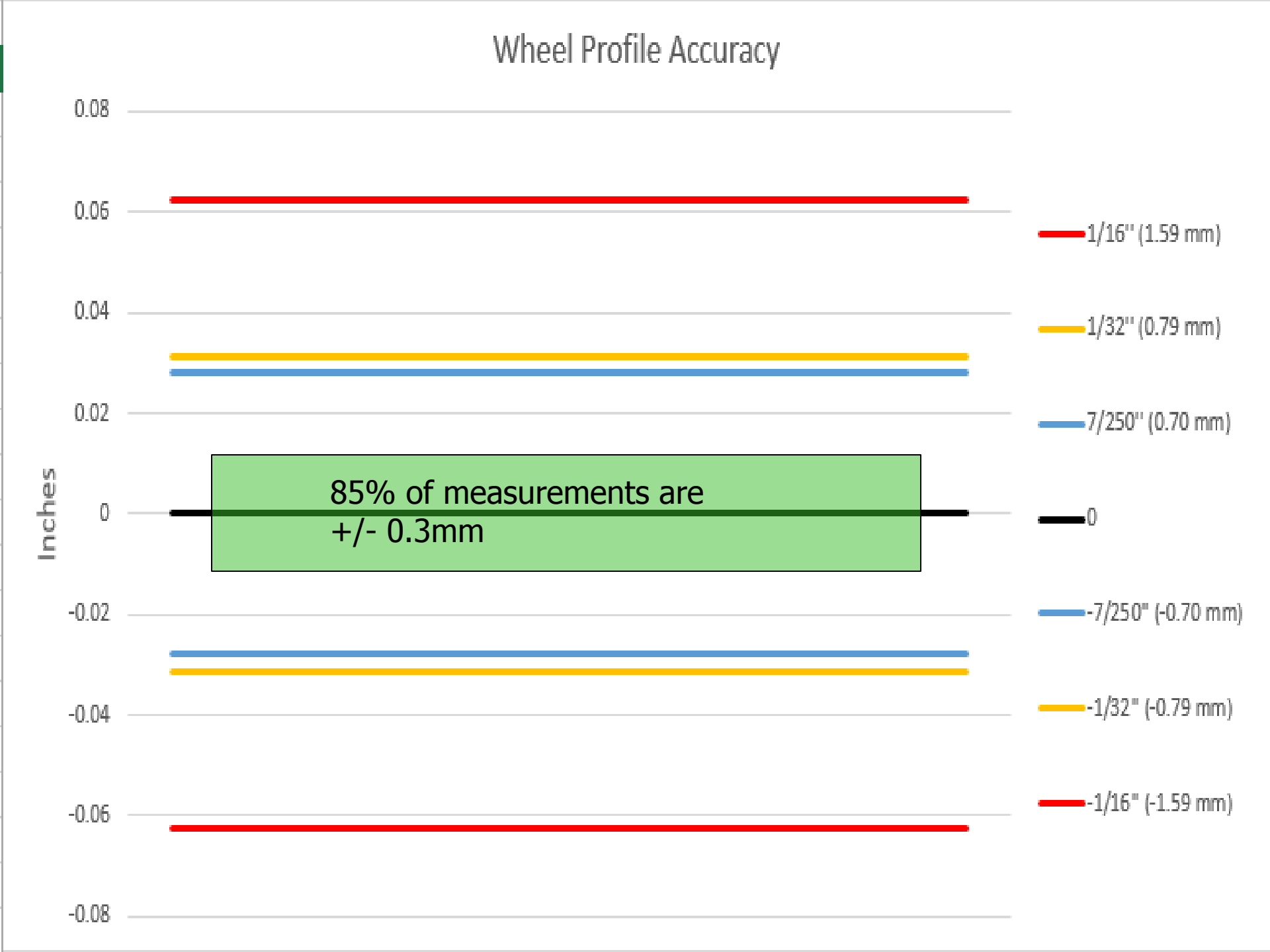
Flange Thickness




Wheel Profile Accuracy
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Inches
1/16" (1.59 mm)
0
-1/16" (-1.59 mm)


Wheel Profile Accuracy
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Inches
1/16" (1.59 mm)
1/32" (0.79 mm)
0
-1/32" (-0.79 mm)
-1/16" (-1.59 mm)


Wheel Profile Accuracy
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Inches
1/16" (1.59 mm)
1/32" (0.79 mm)
7/250" (0.70 mm)
0
-7/250" (-0.70 mm)
-1/32" (-0.79 mm)
-1/16" (-1.59 mm)


Wheel Profile Accuracy
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Inches
85% of measurements are
+/- 0.3mm
1/16" (1.59 mm)
1/32" (0.79 mm)
7/250" (0.70 mm)
0
-7/250" (-0.70 mm)
-1/32" (-0.79 mm)
-1/16" (-1.59 mm)

Reporter

Reporter

- The Report Module is responsible for sending emails to a recipient list
- List of message types:
  - Train Reports
    - Contains information about the train tested
    - Lists all of the wheels which are non conforming
  - Critical Error Report
    - Contains information about a system fault, hardware error, or some other critical event
  - Daily Processing Report
    - Contains system health information

Reporter – Train Report

- **Train Summary Report**
  //

  Train Information

  Train Number : 514
  Arrival Date/Time : 2009/10/14 - 13:06:26
  Axle Count : 176
  Near Side Wheel Count : 176
  Far Wheel Count : 176
  Train Direction : N
  Train Speed : 58 (MPH)
  Near Process Rate : 99%
  Far Process Rate : 100%
  Overall Process Rate : 99.5%
  Labeling Method: Tag
  Total Locos : 2
  Tagged Locos : 2
  Total Railcars : 41
  Tagged Railcars : 41

Reporter – Fault Report

- Fault Information
  //

- Fault Count : 2

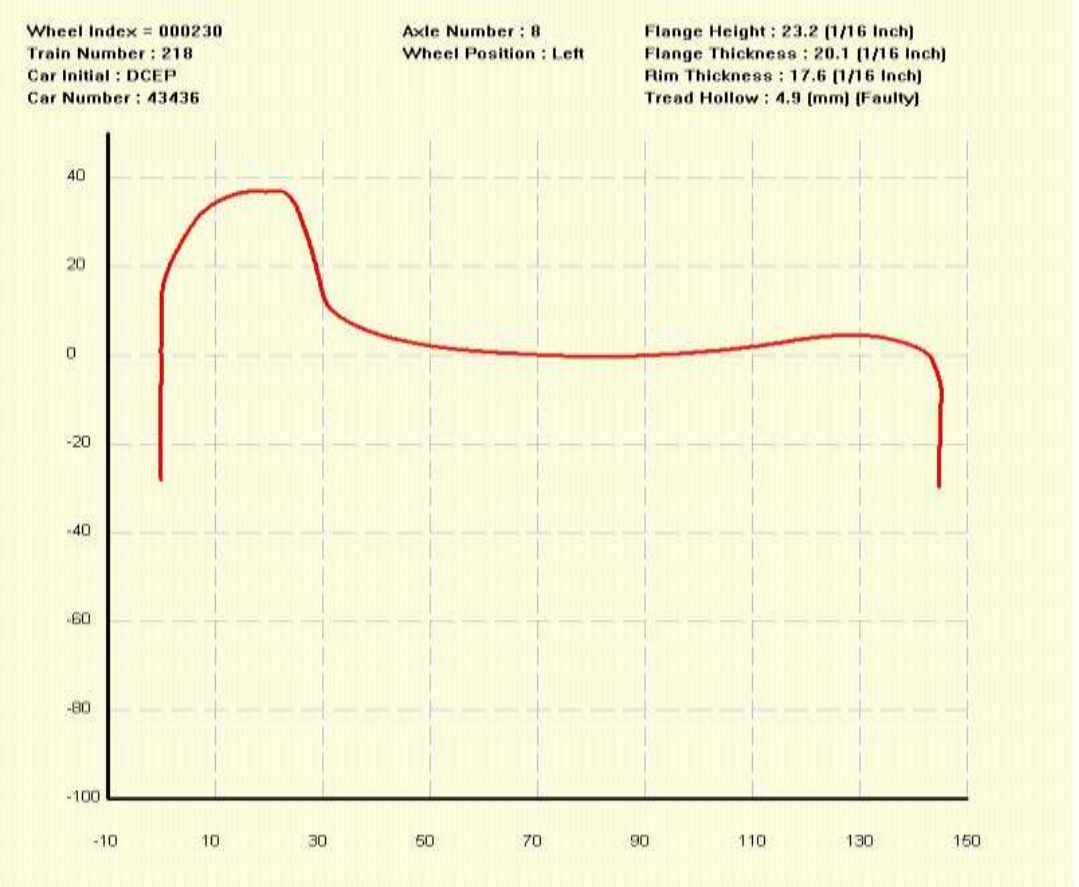
  Fault Number : 1
  Wheel Index : 000188
  Fault Flag : Hollow Tread
  Car Initial : [redacted] Car Number : 360778
  Wheel Position : Right Axle Number : 7

- Flange Height : 22.83 (1/16 inch)
  Flange Thickness : 18.66 (1/16 inch)
  Rim Thickness : 21.92 (1/16 inch)
  Tread Hollow : 4.31 (mm)

  Fault Number : 2
  Wheel Index : 000316
  Fault Flag : Hollow Tread
  Car Initial : [redacted] Car Number : 620963
  Wheel Position : Left Axle Number : 10

  Flange Height : 23.23 (1/16 inch)
  Flange Thickness : 15.48 (1/16 inch)
  Rim Thickness : 17.87 (1/16 inch)
  Tread Hollow : 4.28 (mm)

Reporter – Fault Report



Advantages Automated Profiling

- More frequent inspections/ Measurements
- Trending predicts wear limits - and to evaluate consistency – system provides self evaluation/correction.
- Provides historical data.
- Provides alarms for repair purposes.

Example:

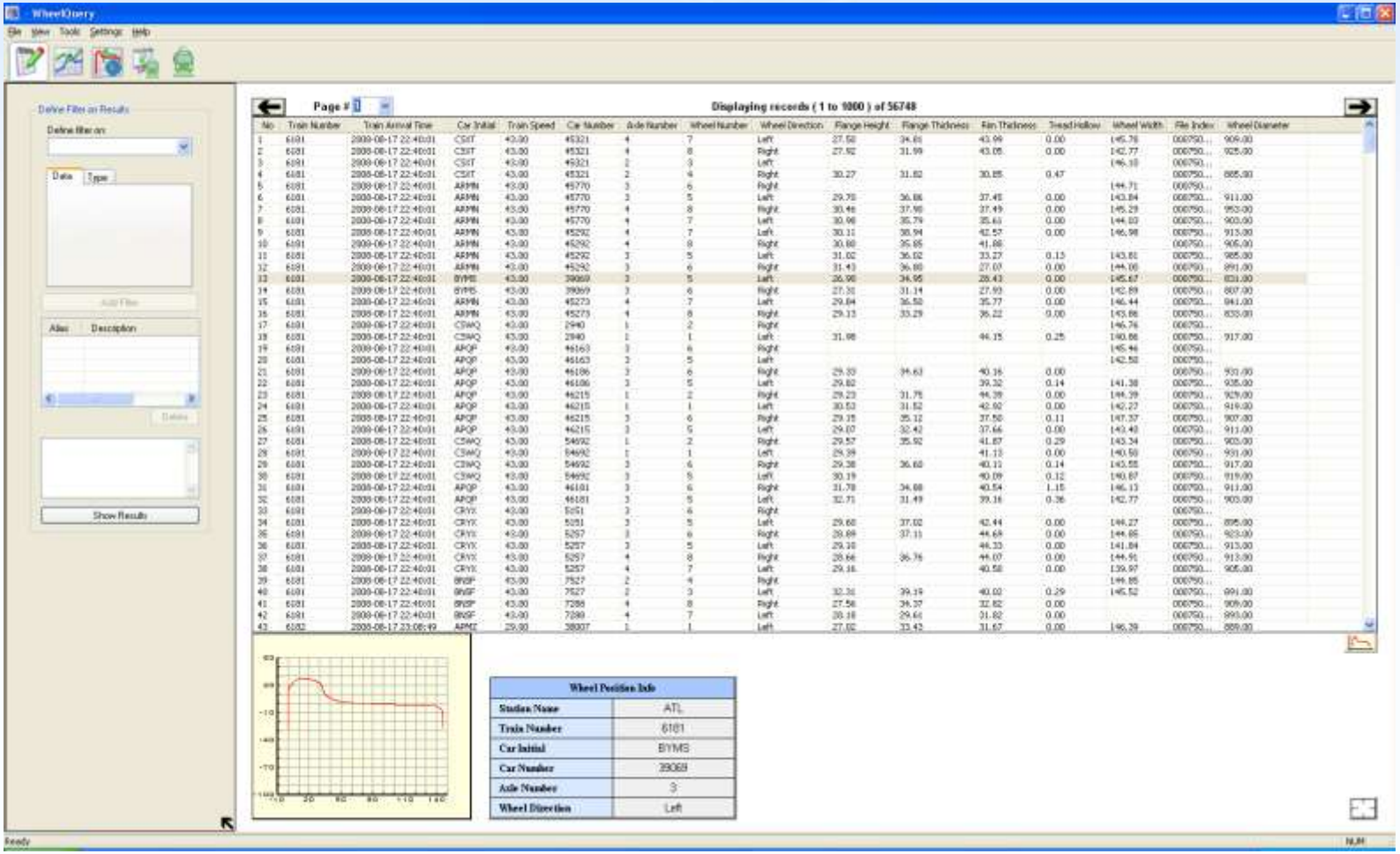
- One wheel profiler at one mainline location for one week.
  - 257 Trains
  - 12189 cars
  - 156128 Wheels
  - 780640 Measurements

Data Trending

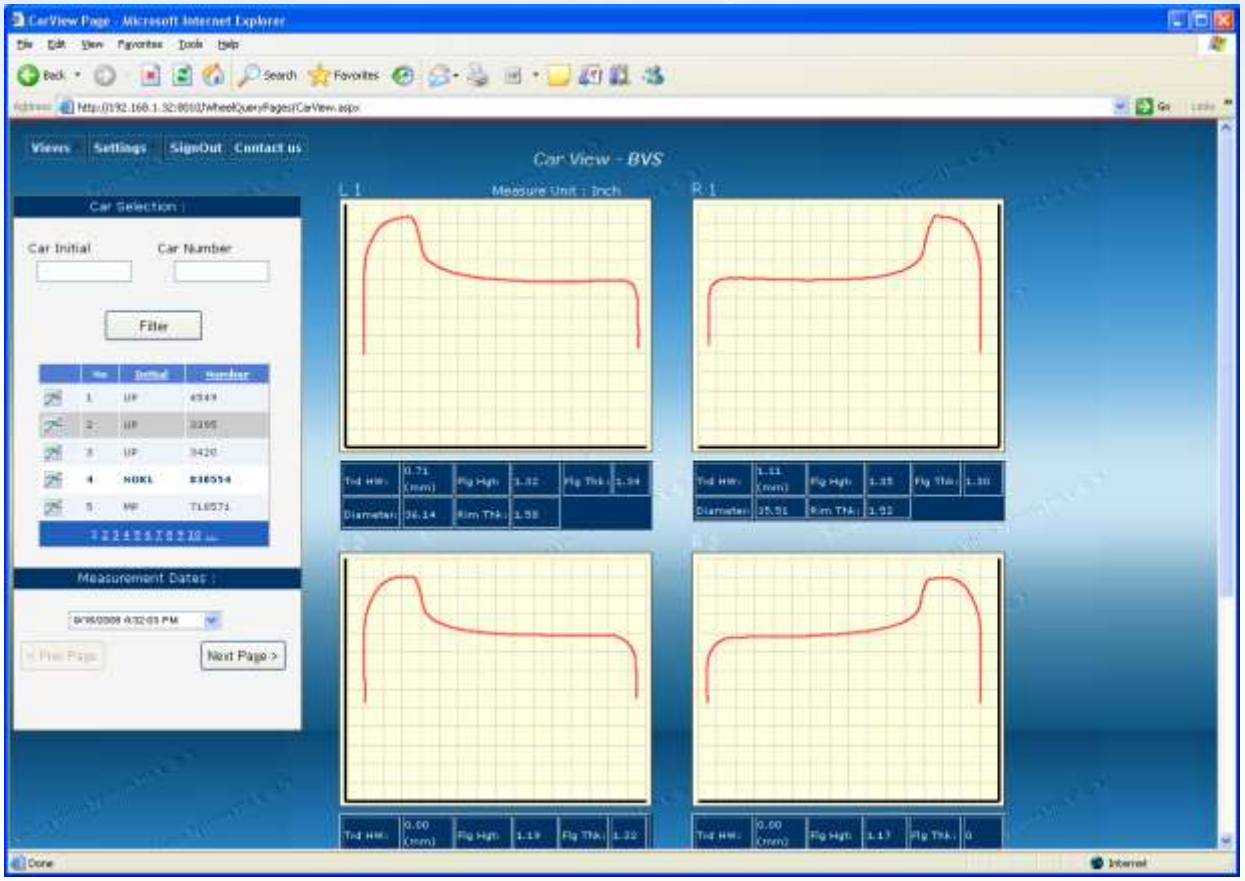
Wheel Query Database

Wheel Query DB

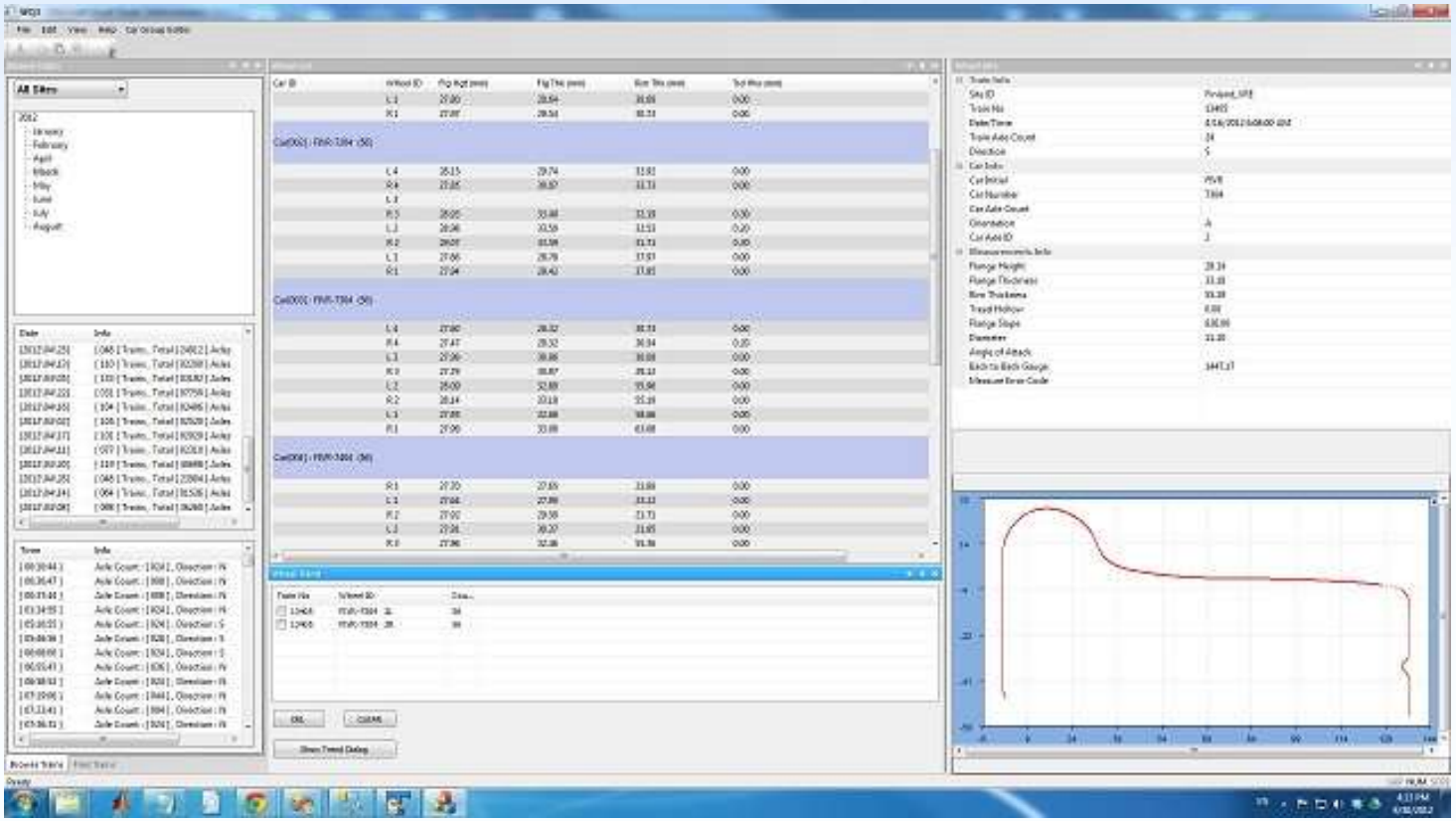
BeenaVision



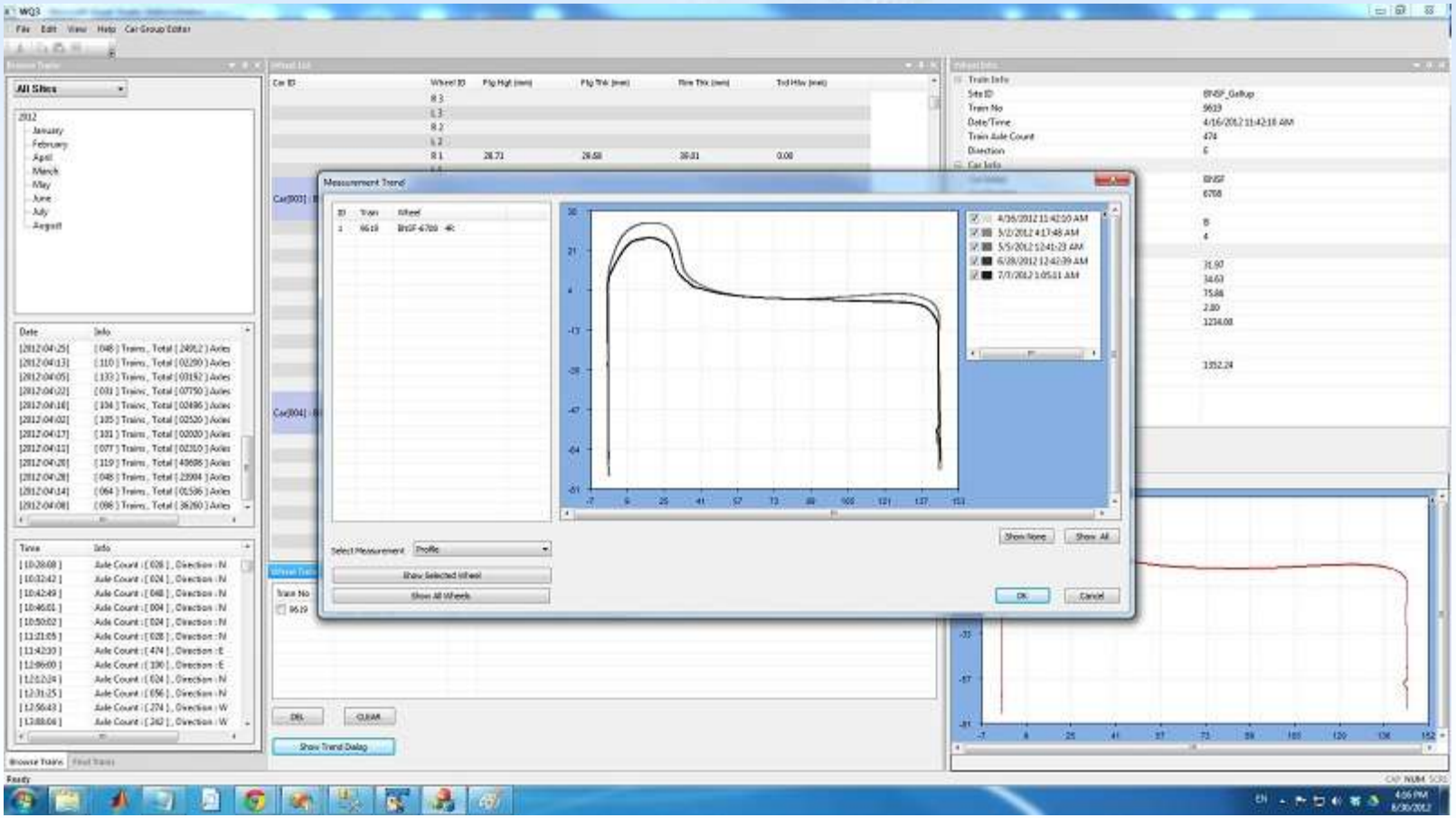
Sample Truck Wheel Profiles



Wheel Query



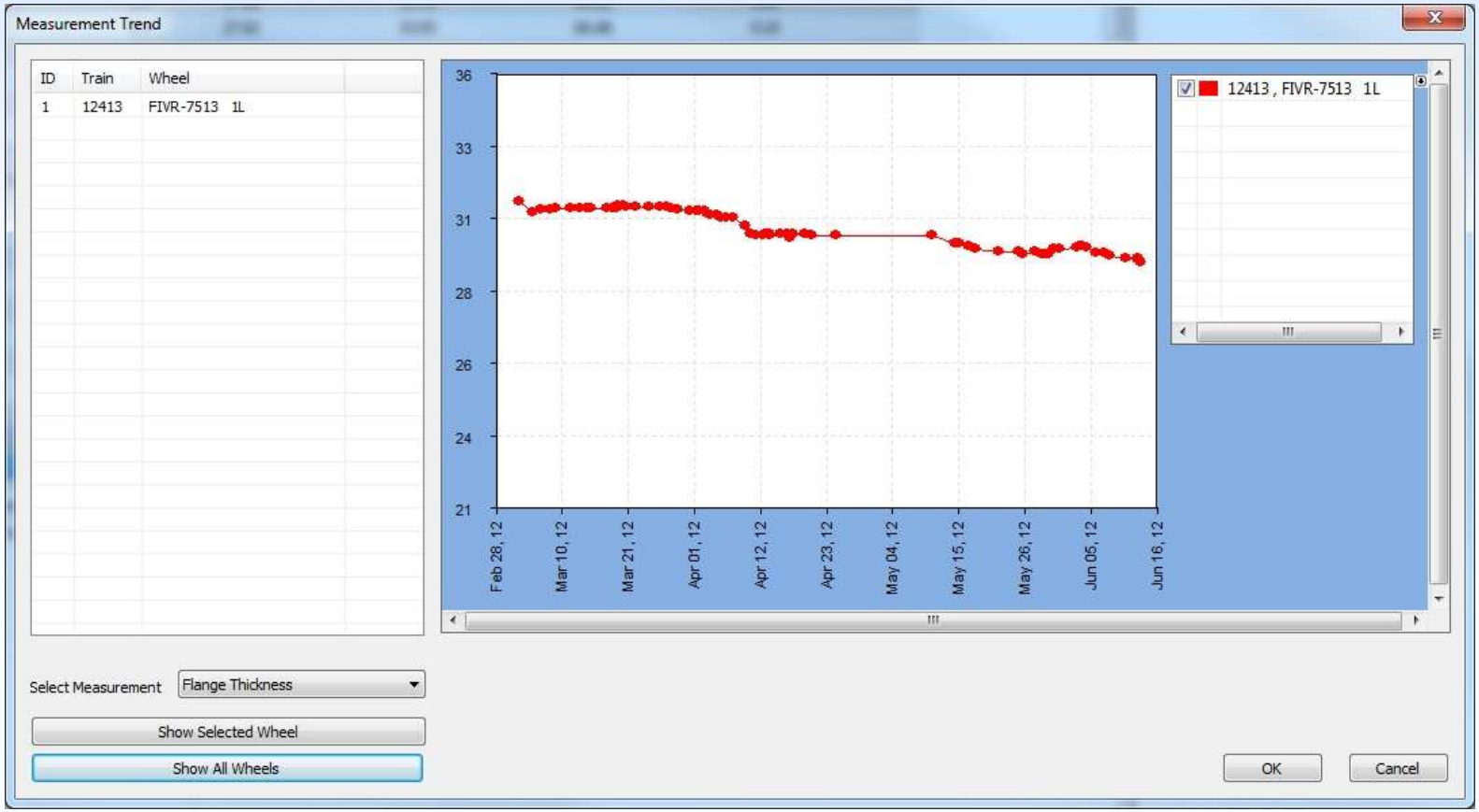
Wheel Change



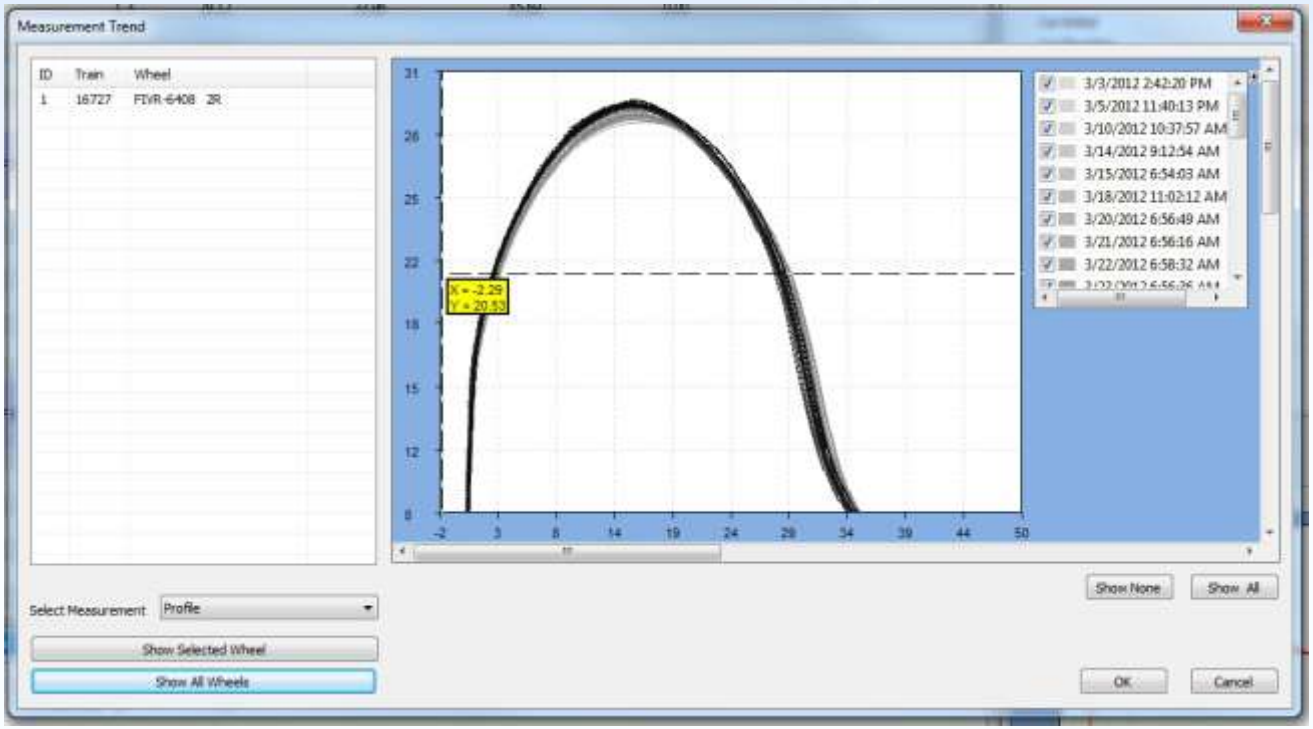
Trending


Measurement Trend
ID
Train
Wheel
1
10116
FIVR-7251 4R
30.3
29.5
28.7
27.8
27.0
26.2
25.3
Feb 28, 12
Mar 10, 12
Mar 22, 12
Apr 02, 12
Apr 13, 12
Apr 25, 12
May 06, 12
May 18, 12
May 29, 12
Jun 09, 12
Jun 21, 12
10116 , FIVR-7251 4R
Select Measurement
Flange Height
Show Selected Wheel
Show All Wheels
OK
Cancel

Trending


Measurement Trend
ID
Train
Wheel
1
12413
FIVR-7513 1L
36
33
31
28
26
24
21
Feb 28, 12
Mar 10, 12
Mar 21, 12
Apr 01, 12
Apr 12, 12
Apr 23, 12
May 04, 12
May 15, 12
May 26, 12
Jun 05, 12
Jun 16, 12
12413 , FIVR-7513 1L
Select Measurement
Flange Thickness
Show Selected Wheel
Show All Wheels
OK
Cancel

Profile Overlay

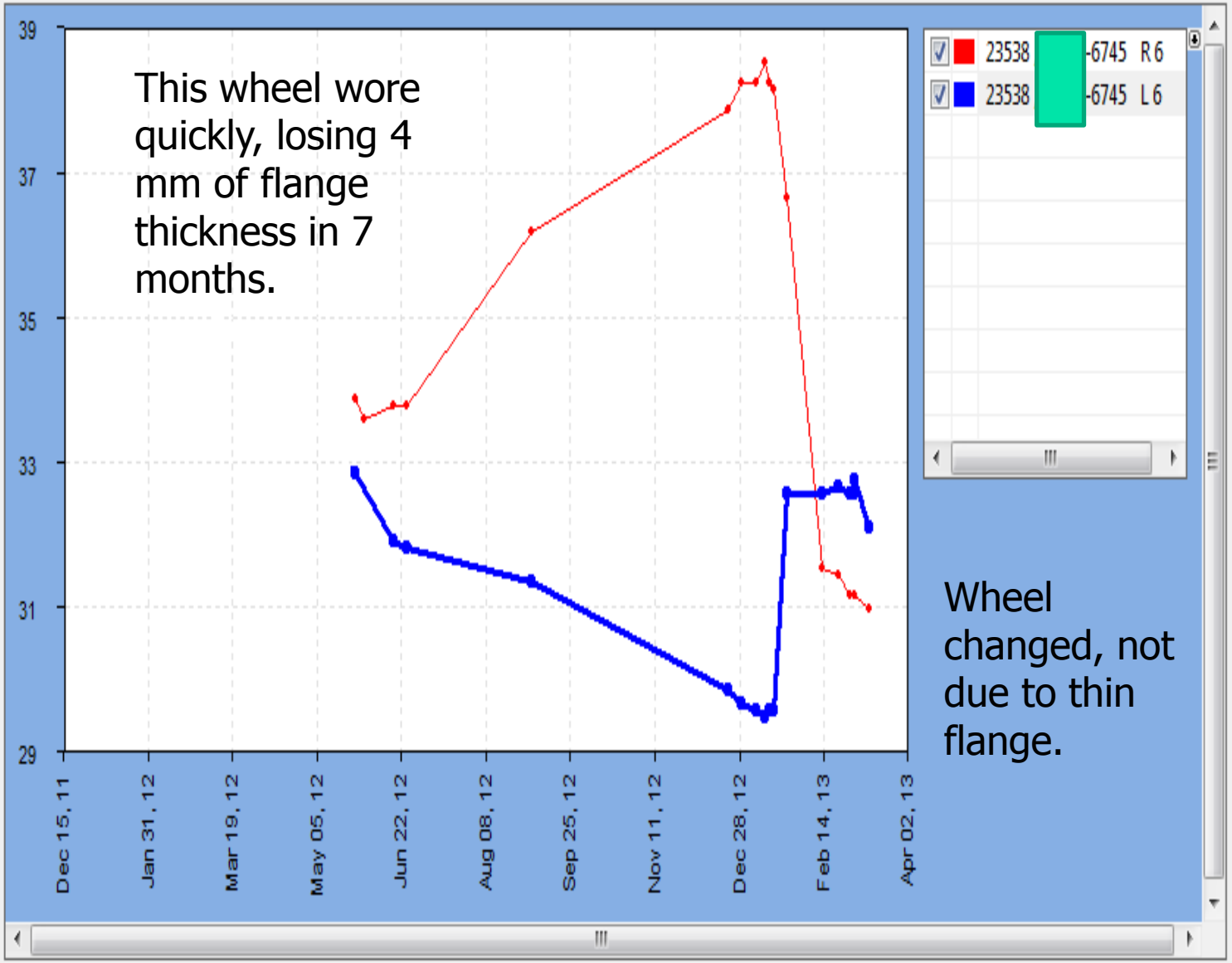


Sample Visuals

Of Profiles and Trends

Measurement Trend

ID	Train	Wheel
1	23538	-6745 R 6
2	23538	-6745 L 6



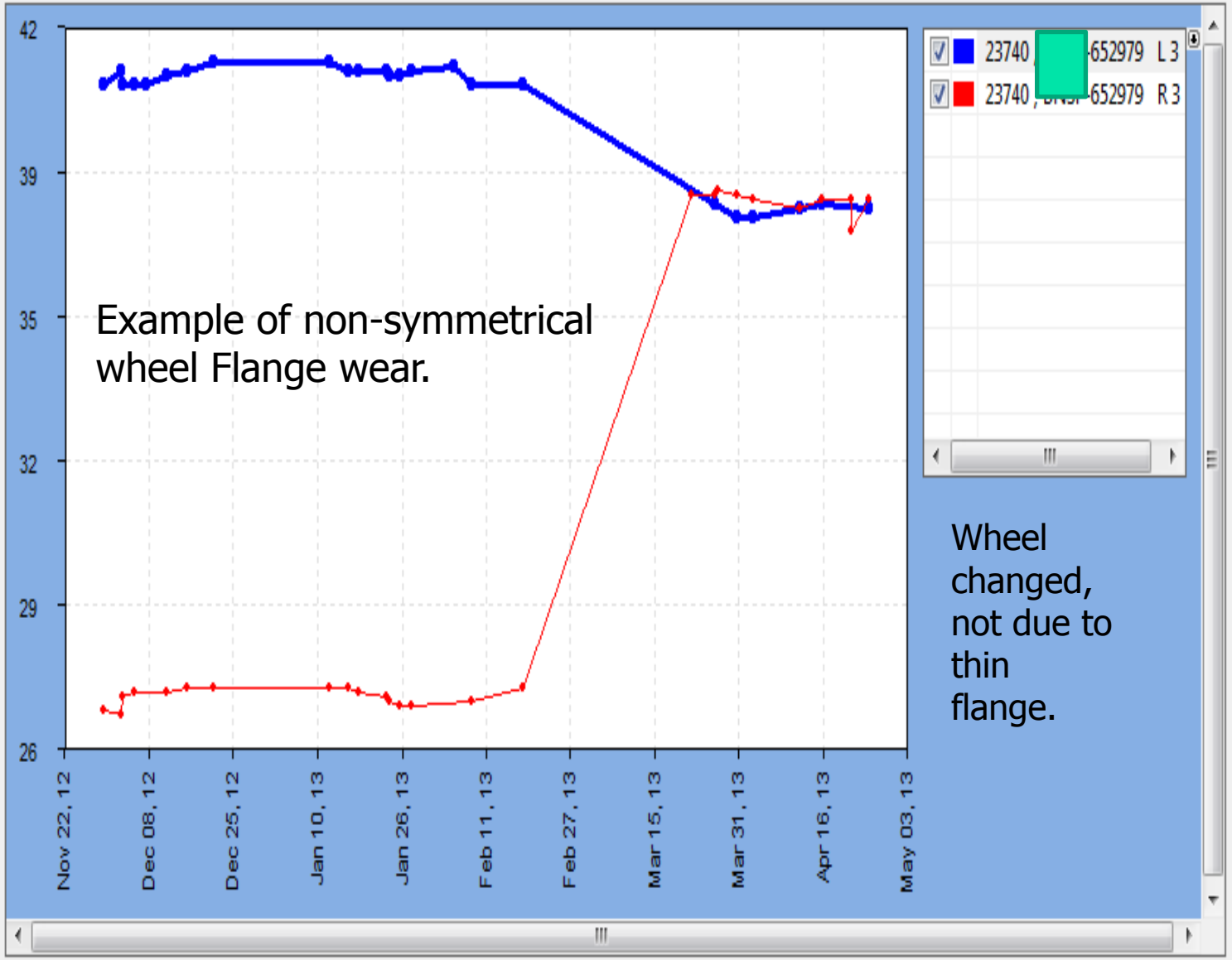
Select Measurement: Flange Thickness

Show Selected Wheel

Show All Wheels

Measurement Trend

ID	Train	Wheel
1	23740	[redacted]-652979 L 3
2	23740	[redacted]-652979 R 3



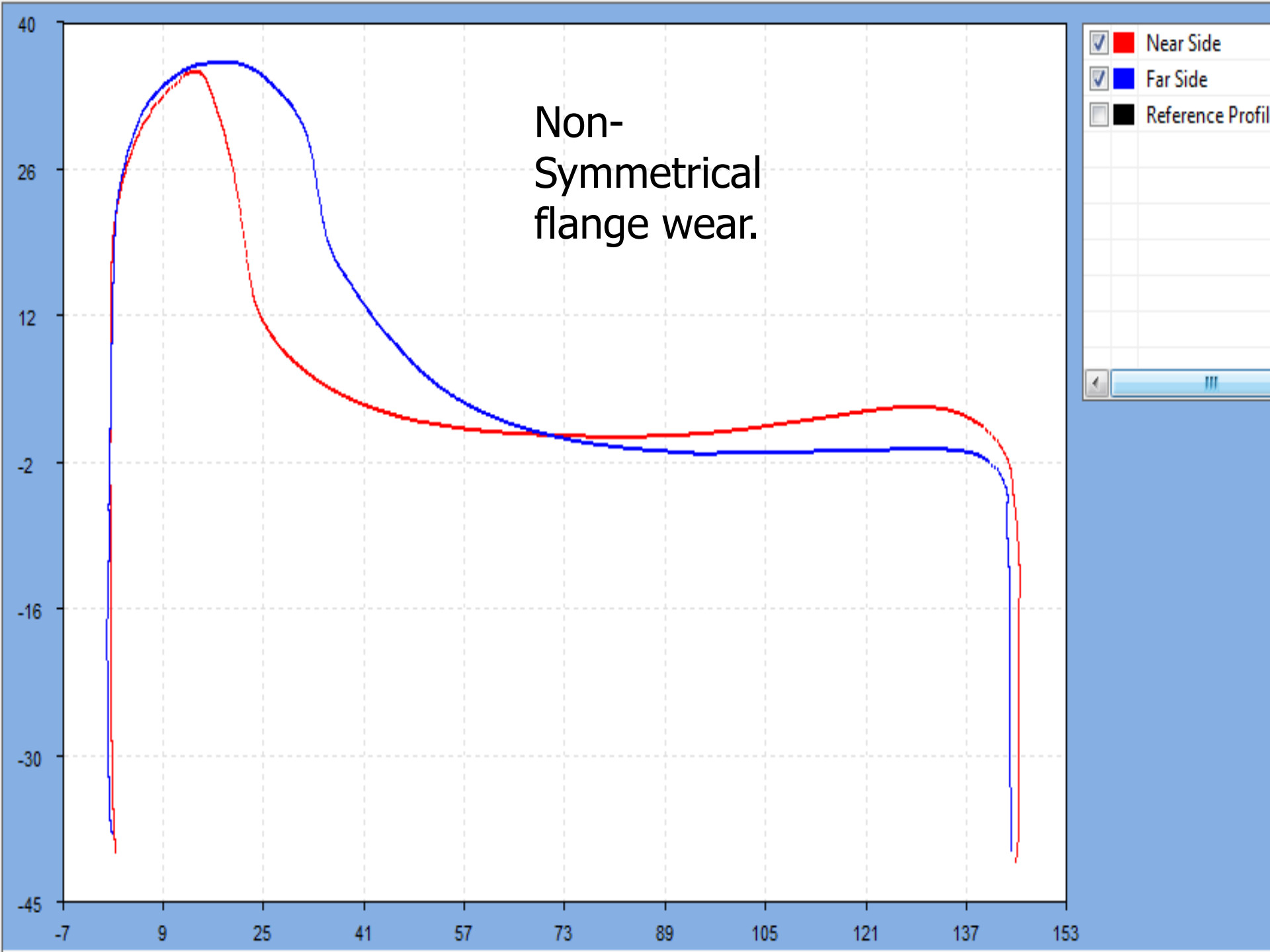
Select Measurement: Flange Thickness

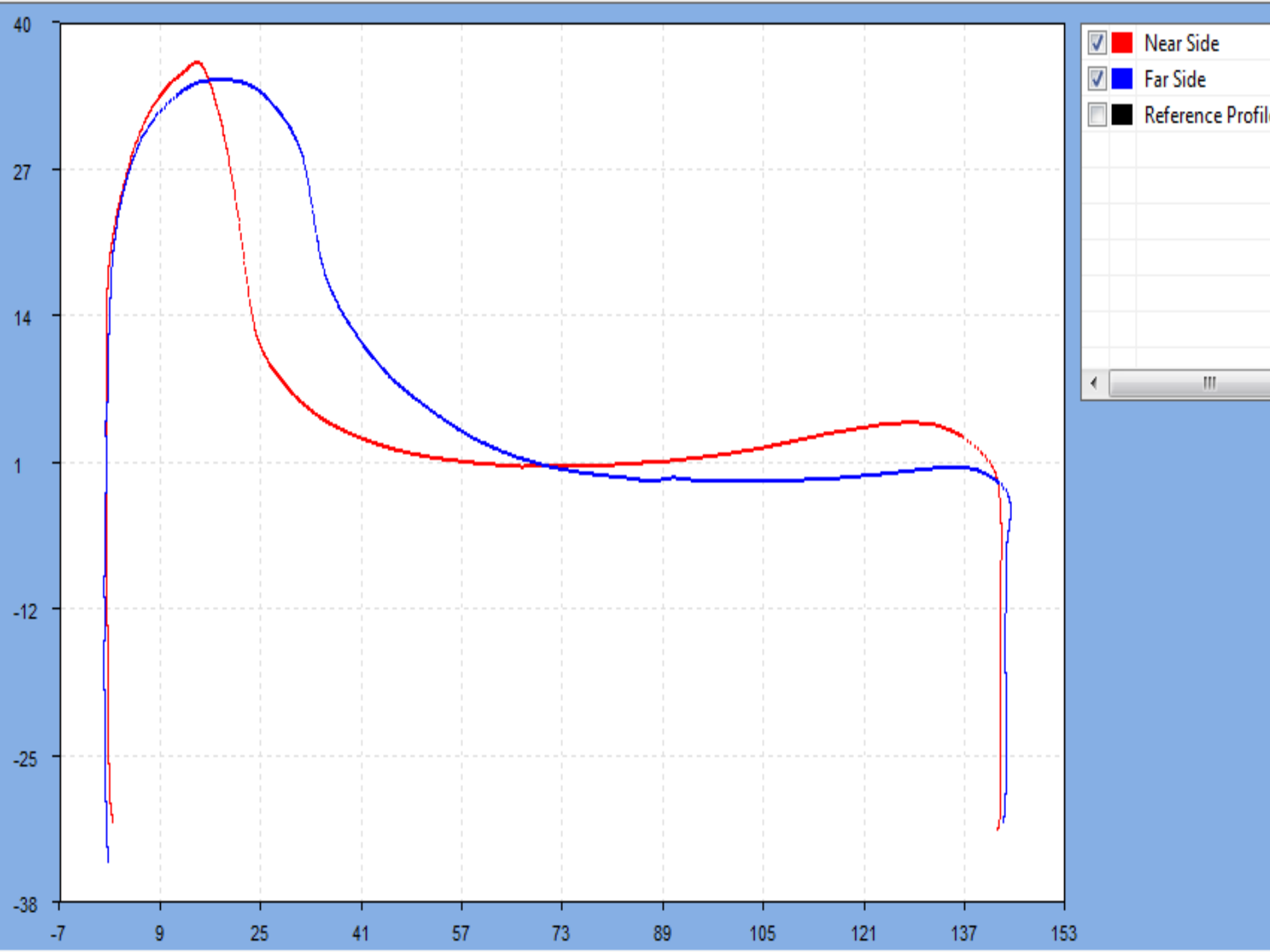
Show Selected Wheel

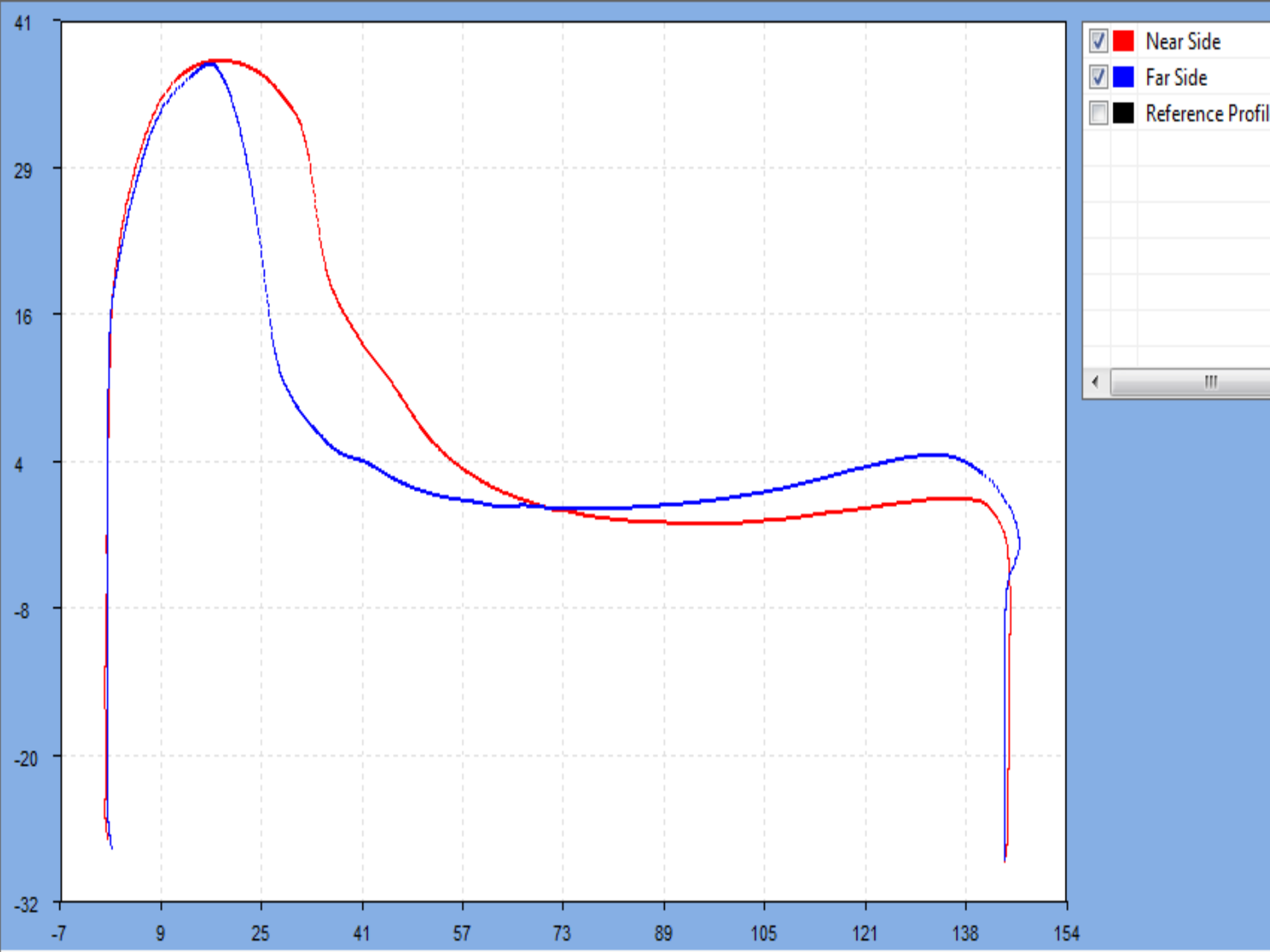
Show All Wheels

Sample Profiles

Large Differences in Flange Thickness


Non-
Symmetrical
flange wear.
Near Side
Far Side
Reference Profil
40
26
12
-2
-16
-30
-45
-7
9
25
41
57
73
89
105
121
137
153

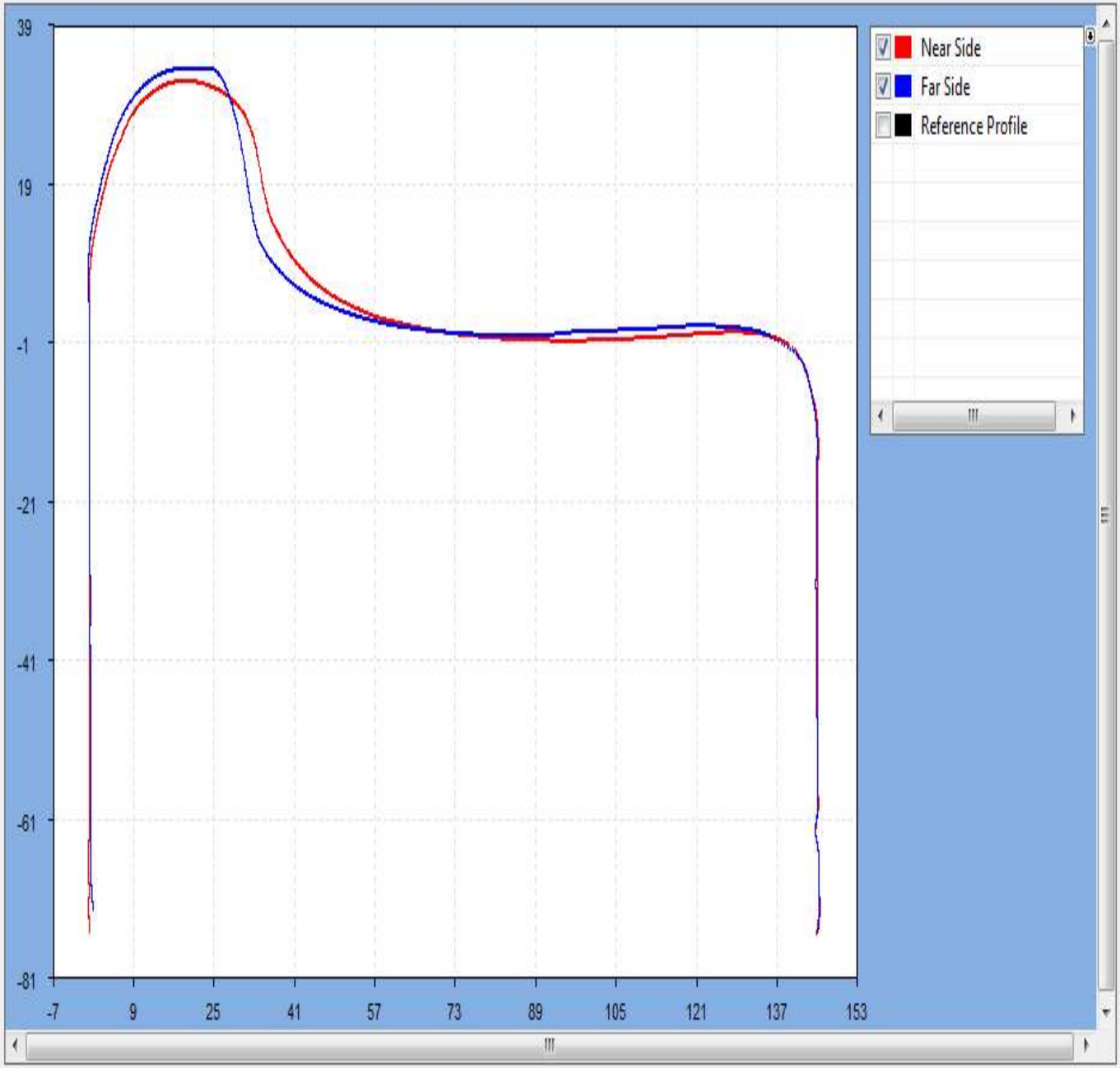

40
27
14
1
-12
-25
-38
-7
9
25
41
57
73
89
105
121
137
153
Near Side
Far Side
Reference Profil


41
29
16
4
-8
-20
-32
-7
9
25
41
57
73
89
105
121
138
154
Near Side
Far Side
Reference Profil

No Mileage data was available, all trending is based on time.

Sample Axle 1

Axle Profile Viewer



Near Side

Auto Align

Far Side

Auto Align

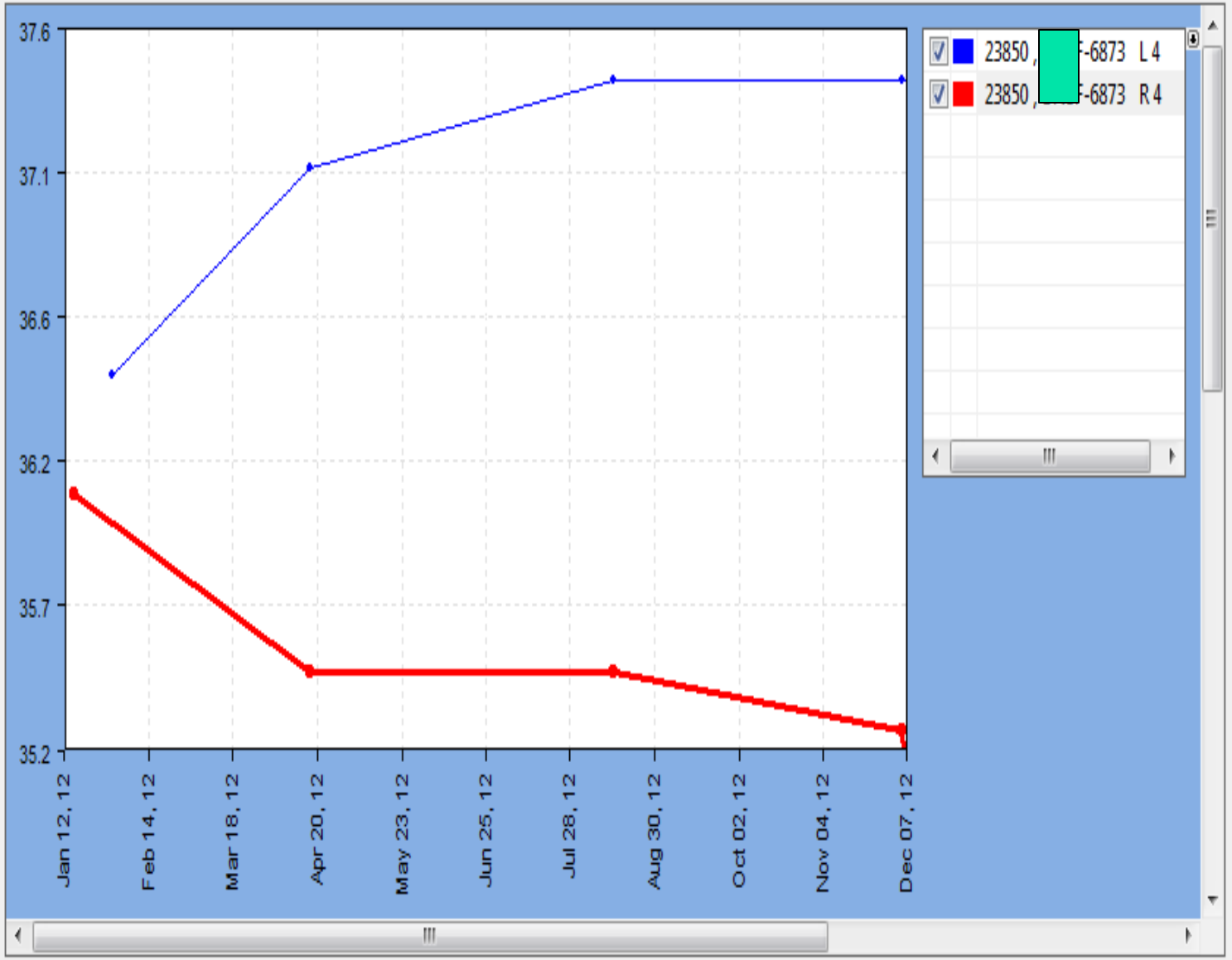
Select Reference Profile: US Narrow Flange

AEI Info

Train : 18690
Car [redacted] - 6873
Time : 12/13/2012 3:45:27 AM
Near Side : Left
Far Side : Right

Measurement Trend

ID	Train	Wheel
1	23850	[redacted]6873 L 4
2	23850	[redacted]6873 R 4



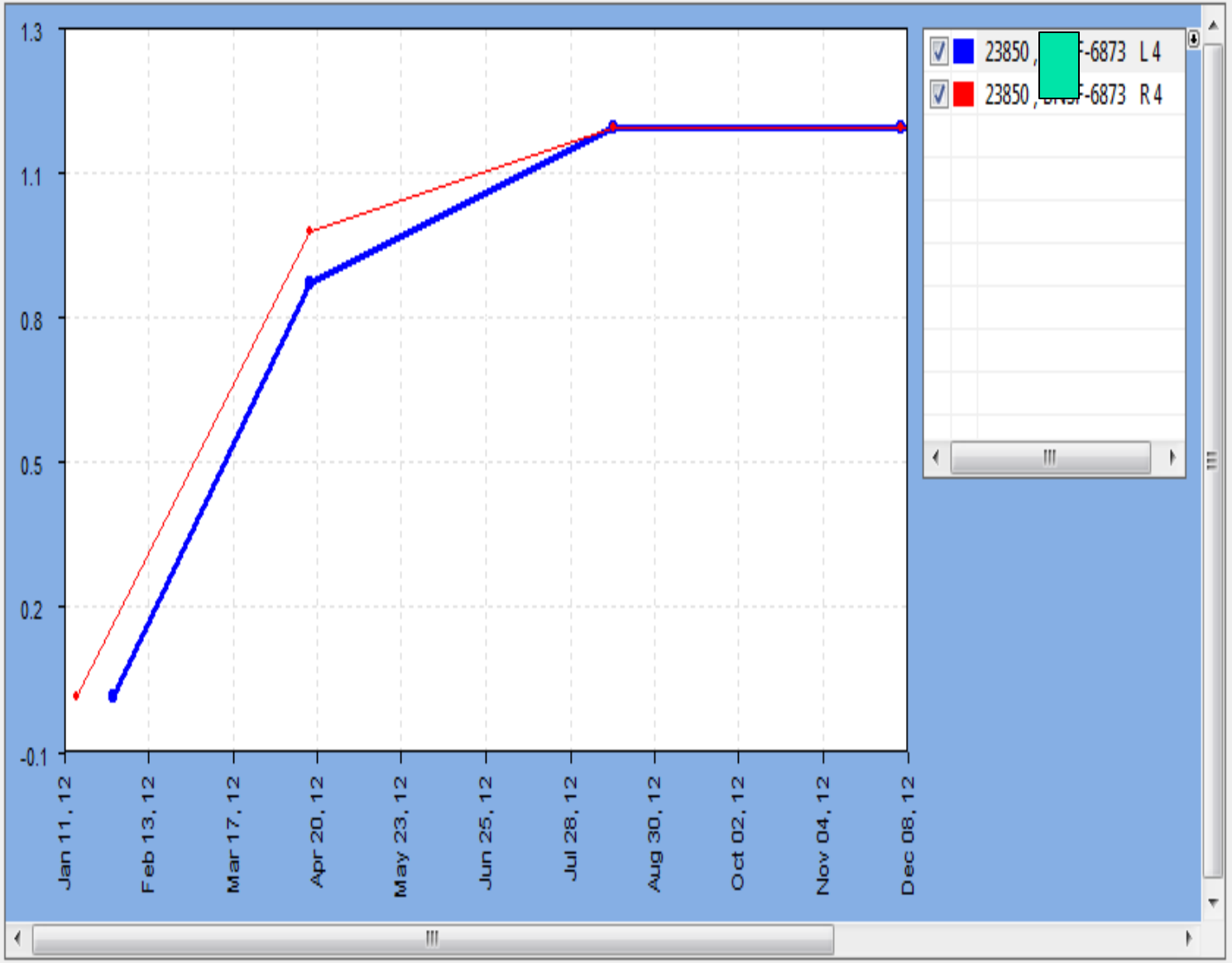
Select Measurement: Flange Thickness

Show Selected Wheel

Show All Wheels

Measurement Trend

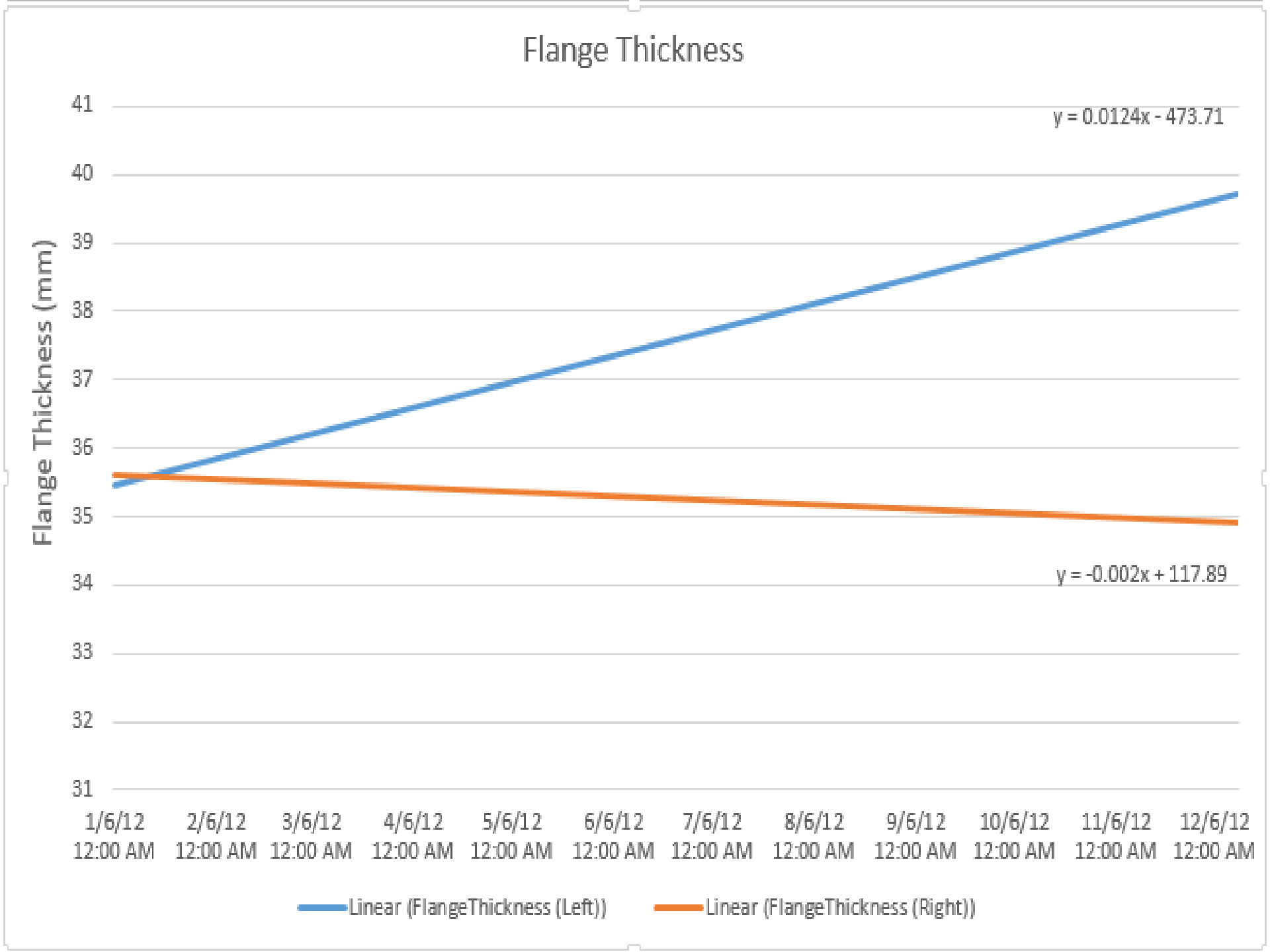
ID	Train	Wheel
1	23850	[redacted]6873 L 4
2	23850	[redacted]6873 R 4



Select Measurement: Tread Hollow

Show Selected Wheel

Show All Wheels


Flange Thickness
Flange Thickness (mm)
41
40
39
38
37
36
35
34
33
32
31
y = 0.0124x - 473.71
y = -0.002x + 117.89
1/6/12 12:00 AM
2/6/12 12:00 AM
3/6/12 12:00 AM
4/6/12 12:00 AM
5/6/12 12:00 AM
6/6/12 12:00 AM
7/6/12 12:00 AM
8/6/12 12:00 AM
9/6/12 12:00 AM
10/6/12 12:00 AM
11/6/12 12:00 AM
12/6/12 12:00 AM
Linear (FlangeThickness (Left))
Linear (FlangeThickness (Right))

Months to non-compliance

Range: January – December (12 months)

Earliest Flange Thickness Measurement: 1.42″ (36.0 mm)

Latest Flange Thickness Measurement: 1.39″ (35.2 mm)

Amount of wear per month:

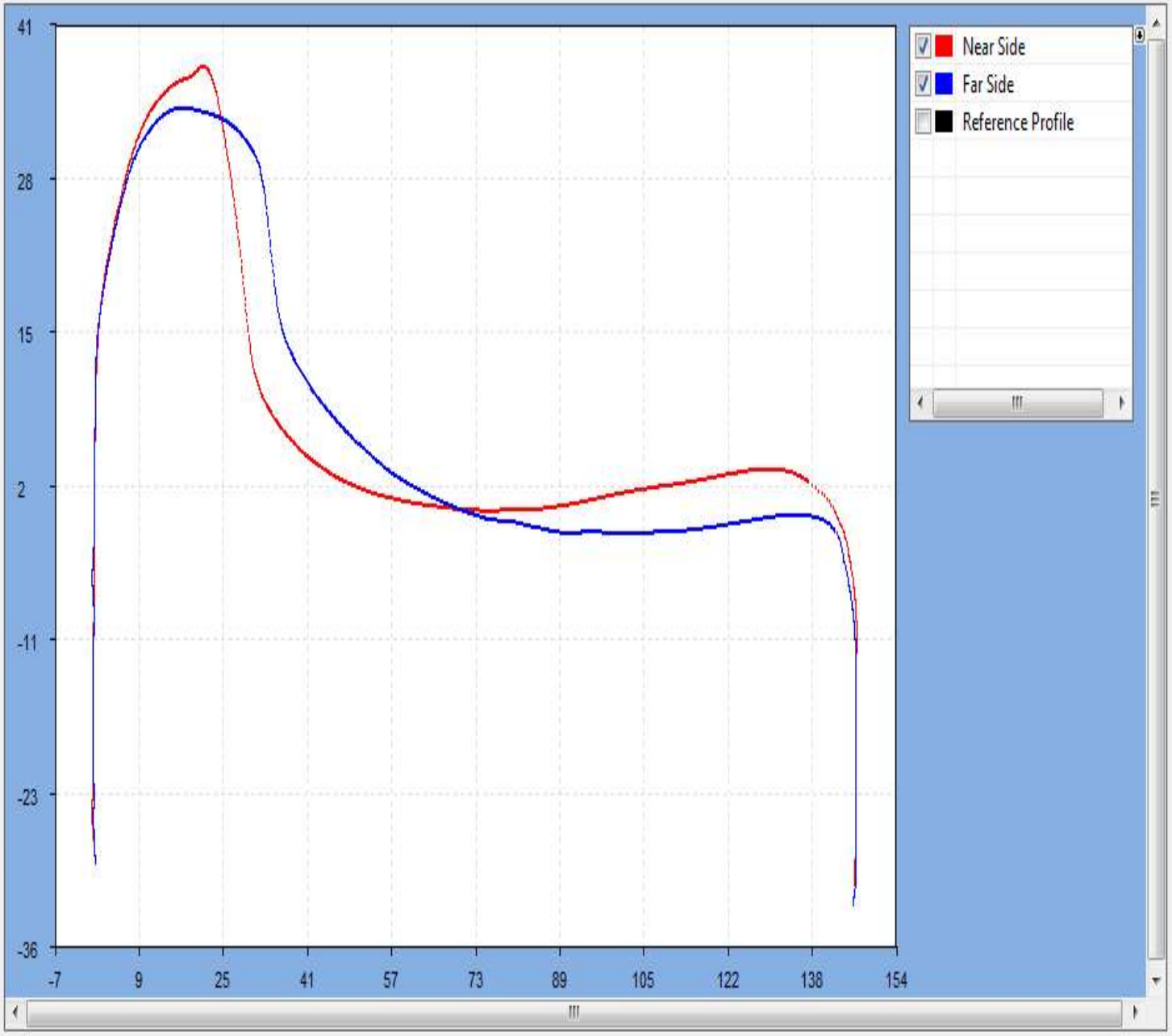
$$\frac{FT_{Begin} - FT_{End}}{Number\ of\ Months} = \frac{1.42 - 1.39}{12} = 0.003'' \textbf{ (0.07 mm)} \text{ per month}$$

Projected Number of Months Left until Considered Dead by FRA ($\frac{7}{8}''$):

$$\left\lfloor \frac{FT_{End} - FT_{FRA}}{Inches\ per\ month} \right\rfloor = \left\lfloor \frac{1.39 - \frac{7}{8}}{0.003} \right\rfloor = 171 \text{ Months left (Before thin flange)}$$

Sample Axle 2

Axle Profile Viewer



Near Side

Auto Align

Far Side

Auto Align

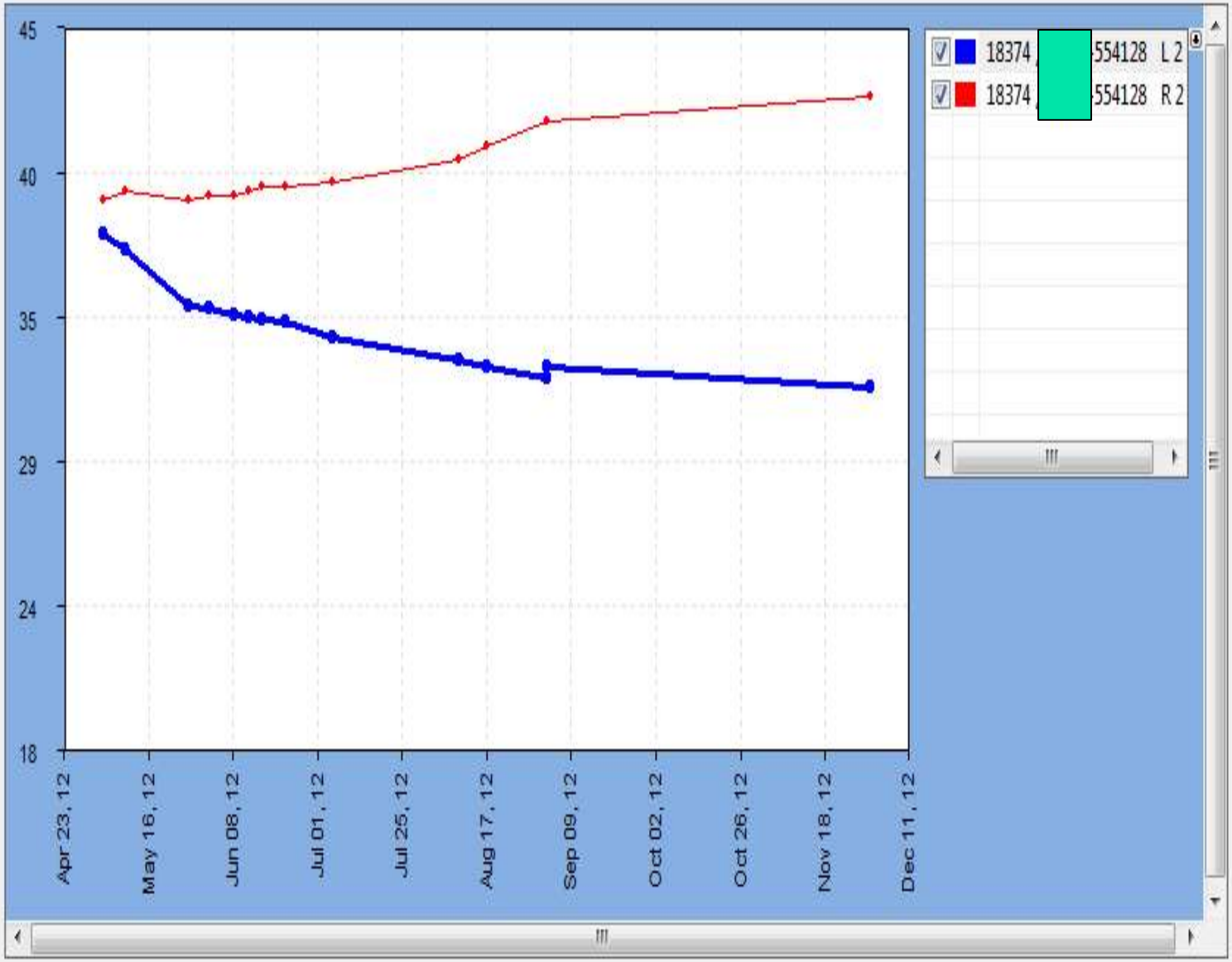
Select Reference Profile: US Narrow Flange

AEI Info

Train : 18374
Car : [redacted] 554128
Time : 12/5/2012 2:40:18 PM
Near Side : Left
Far Side : Right

Measurement Trend

ID	Train	Wheel
1	18374	[redacted] 554128 L 2
2	18374	[redacted] 554128 R 2



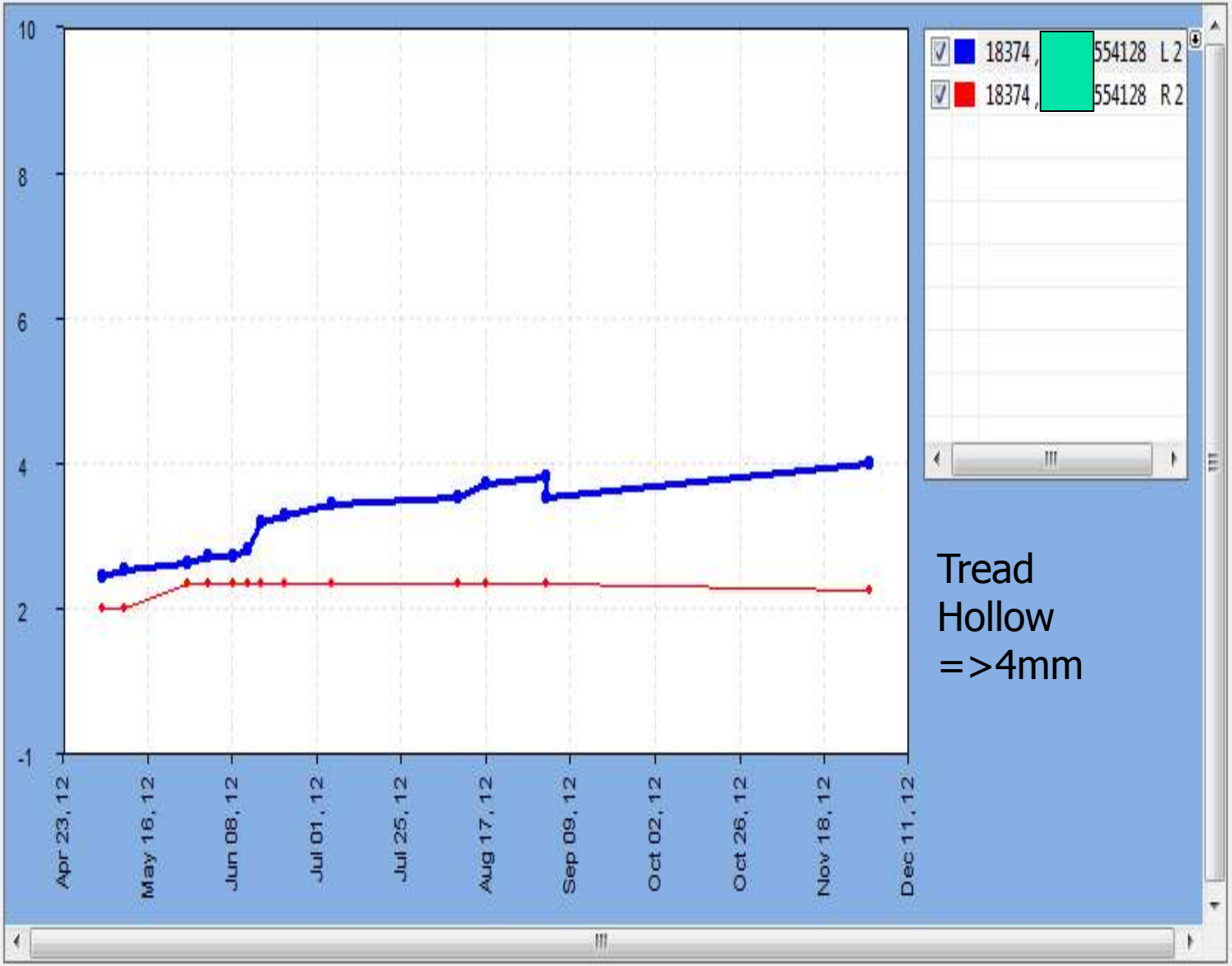
Select Measurement: Flange Thickness

Show Selected Wheel

Show All Wheels

Measurement Trend

ID	Train	Wheel
1	18374	[redacted]-554128 L 2
2	18374	[redacted]-554128 R 2

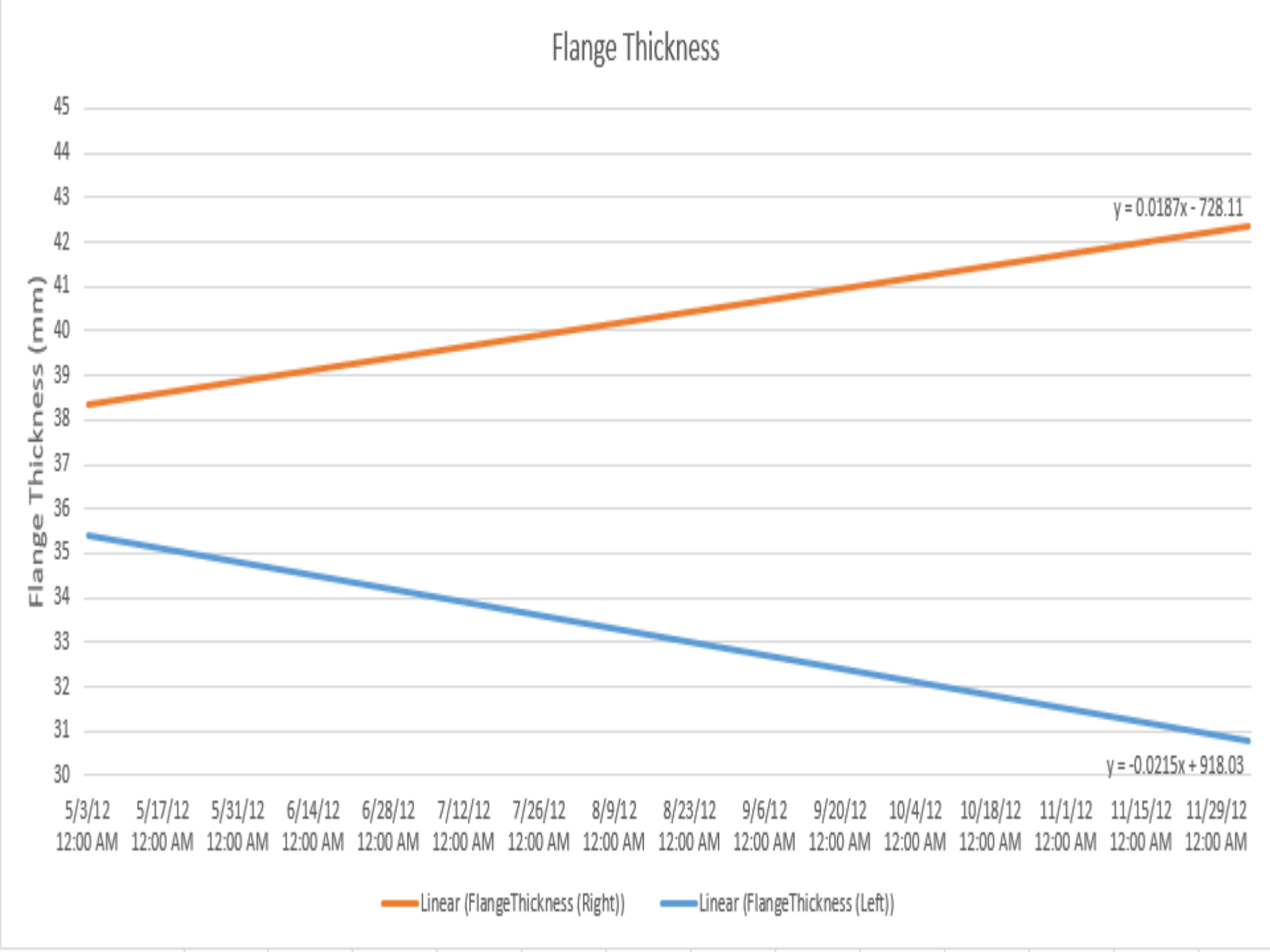


Tread Hollow =>4mm

Select Measurement: Tread Hollow

Show Selected Wheel

Show All Wheels


Flange Thickness
Flange Thickness (mm)
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
y = 0.0187x - 728.11
y = -0.0215x + 918.03
5/3/12 12:00 AM
5/17/12 12:00 AM
5/31/12 12:00 AM
6/14/12 12:00 AM
6/28/12 12:00 AM
7/12/12 12:00 AM
7/26/12 12:00 AM
8/9/12 12:00 AM
8/23/12 12:00 AM
9/6/12 12:00 AM
9/20/12 12:00 AM
10/4/12 12:00 AM
10/18/12 12:00 AM
11/1/12 12:00 AM
11/15/12 12:00 AM
11/29/12 12:00 AM
Linear (FlangeThickness (Right))
Linear (FlangeThickness (Left))

Months to non-compliance

Range: May – December (8 months)

Flange Thickness in May: 1.47″ (37.3 mm)

Flange Thickness in December: 1.25″ (31.7 mm)

Amount of wear per month:

$$\frac{FT_{Begin} - FT_{End}}{Number\ of\ Months} = \frac{1.47 - 1.25}{8} = 0.03 \text{ inches } \mathbf{(0.7\ mm)} \text{ per month}$$

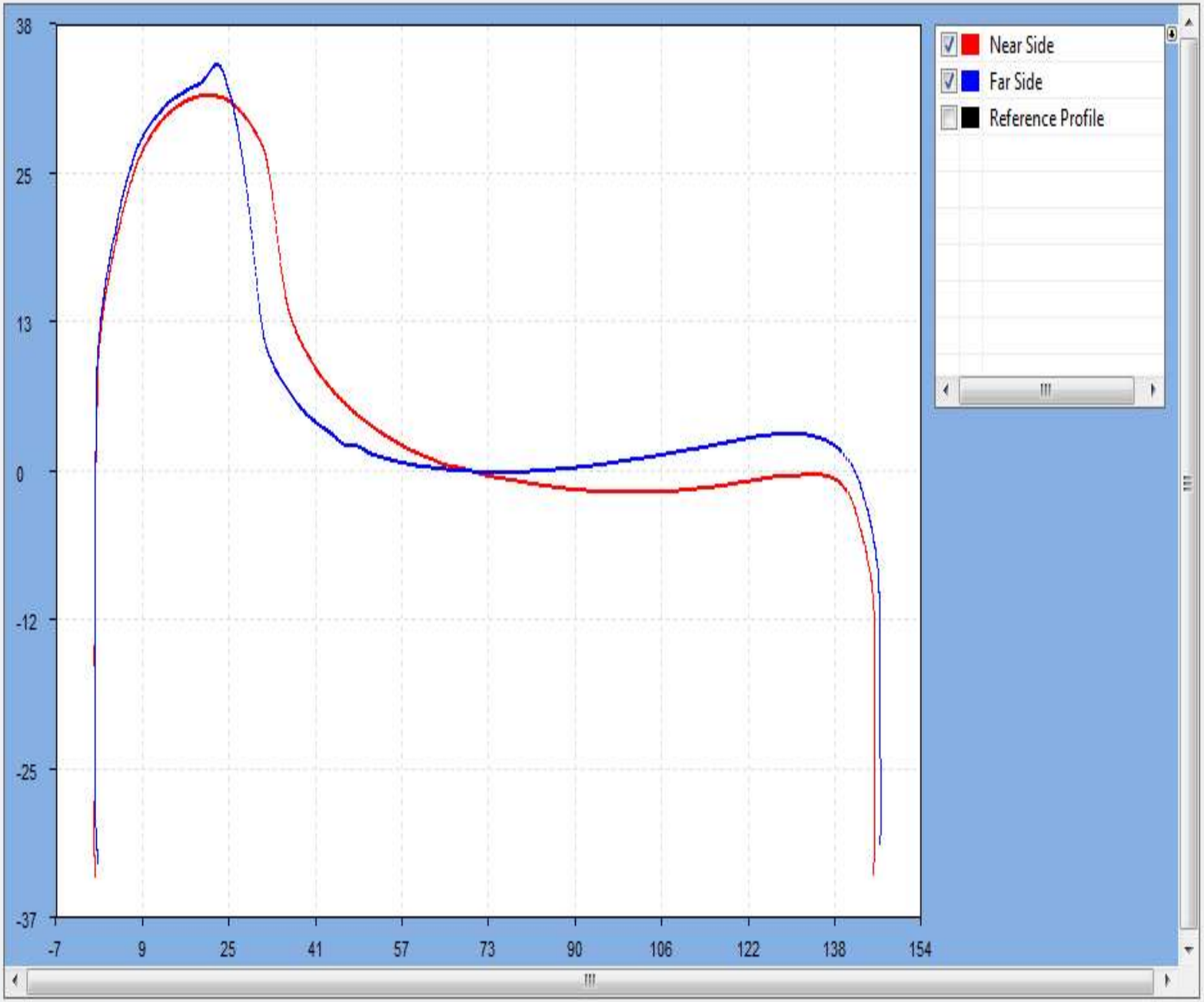
Projected Number of Months Left until Considered Dead by FRA ($\frac{7}{8}$″):

$$\left\lfloor \frac{FT_{End} - FT_{FRA}}{Inches\ per\ month} \right\rfloor = \left\lfloor \frac{1.25 - \frac{7}{8}}{0.03} \right\rfloor = 12 \text{ Months till Thin Flange}$$

Will probably reach flange height before 12 months.

Sample Axle 3

Axle Profile Viewer



Near Side

Auto Align

Far Side

Auto Align

Select Reference Profile

US Na

AEI Info

Train : 12615
Car [redacted]53957
Time : 7/8/2012 3:42:36 AM
Near Side : Left
Far Side : Right

Measurement Trend

ID	Train	Wheel
1	12615	[redacted]553957 L 4
2	12615	[redacted]553957 R 4

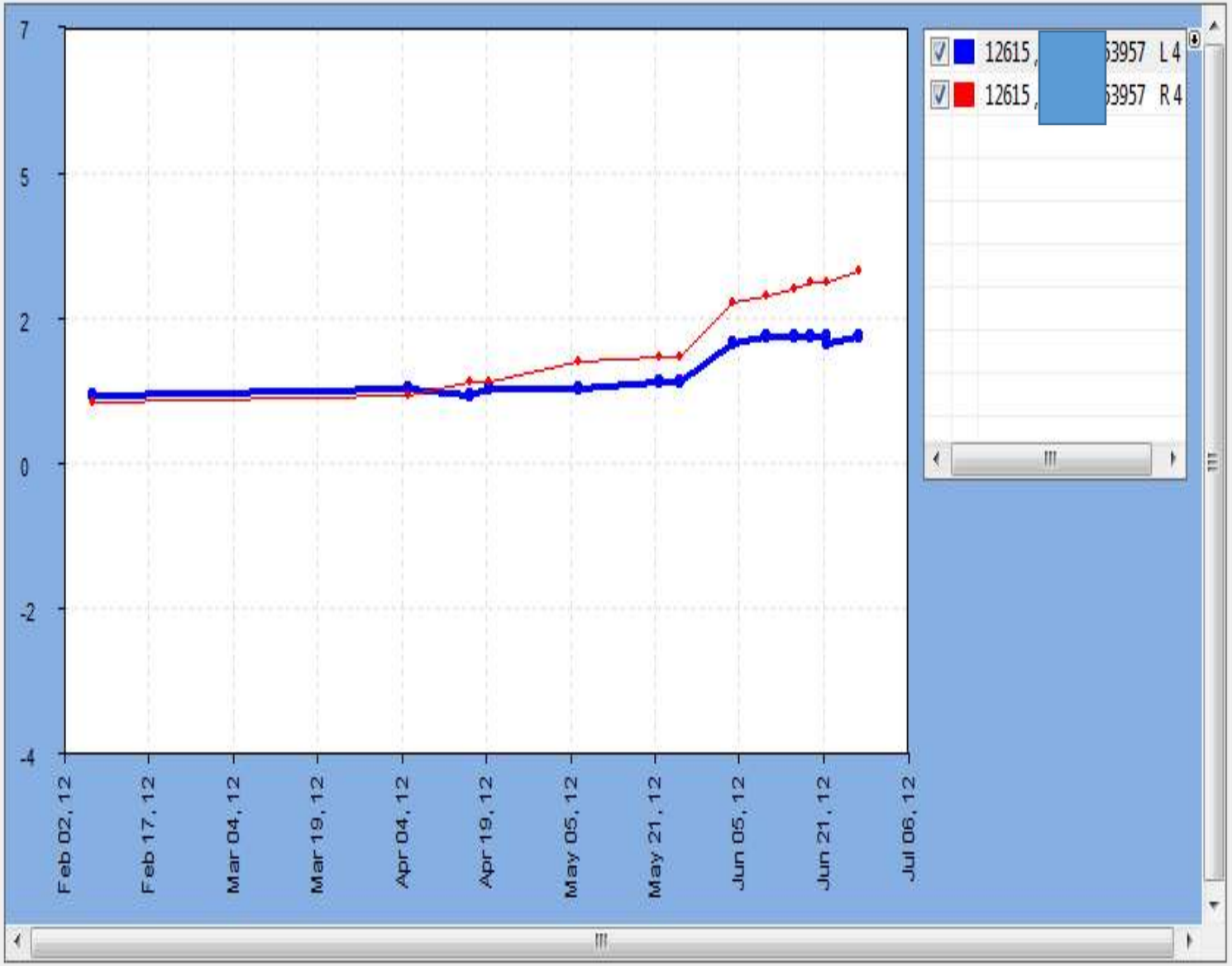
Select Measurement: Flange Thickness

Show Selected Wheel

Show All Wheels

Measurement Trend

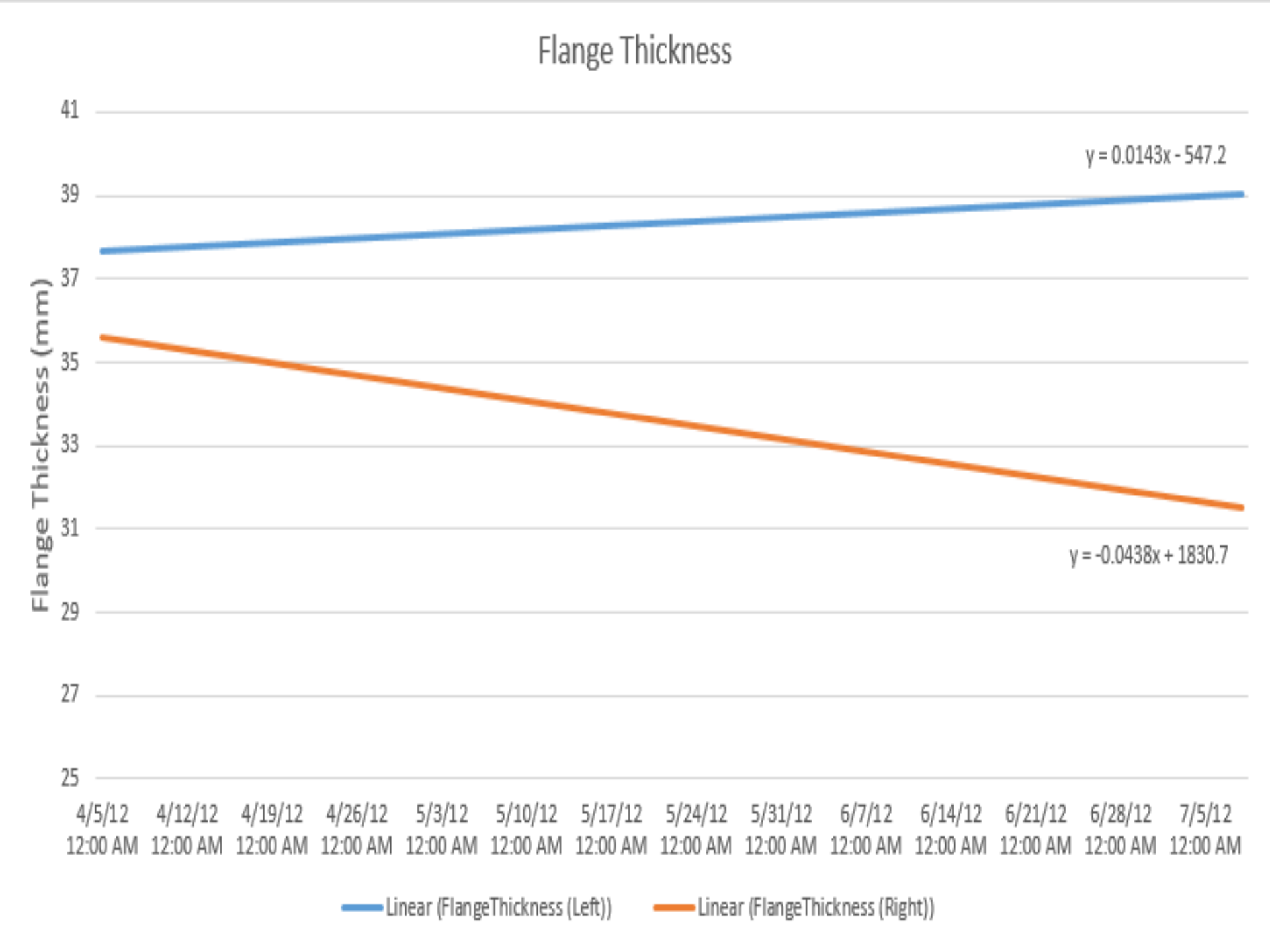
ID	Train	Wheel
1	12615	[redacted]653957 L 4
2	12615	[redacted]653957 R 4



Select Measurement: Tread Hollow

Show Selected Wheel

Show All Wheels


Flange Thickness
41
39
37
35
33
31
29
27
25
Flange Thickness (mm)
y = 0.0143x - 547.2
y = -0.0438x + 1830.7
4/5/12 12:00 AM
4/12/12 12:00 AM
4/19/12 12:00 AM
4/26/12 12:00 AM
5/3/12 12:00 AM
5/10/12 12:00 AM
5/17/12 12:00 AM
5/24/12 12:00 AM
5/31/12 12:00 AM
6/7/12 12:00 AM
6/14/12 12:00 AM
6/21/12 12:00 AM
6/28/12 12:00 AM
7/5/12 12:00 AM
Linear (FlangeThickness (Left))
Linear (FlangeThickness (Right))

Months to Non-Compliance

Range: April – July (4 months)

Flange Thickness in April: 1.42'' (36.0 mm)

Flange Thickness in July: 1.25'' (31.8 mm)

Amount of wear per month:

$$\frac{FT_{Begin} - FT_{End}}{Number\ of\ Months} = \frac{1.42 - 1.25}{4} = 0.0425 \text{ inches}$$

(1.05 mm) per month

Projected Number of Months Left until Considered Dead by FRA ($\frac{7}{8}$''):

$$\left\lfloor \frac{FT_{End} - FT_{FRA}}{Inches\ per\ month} \right\rfloor = \left\lfloor \frac{1.25 - \frac{7}{8}}{0.0425} \right\rfloor = 8 \text{ Months left}$$

What’s next?

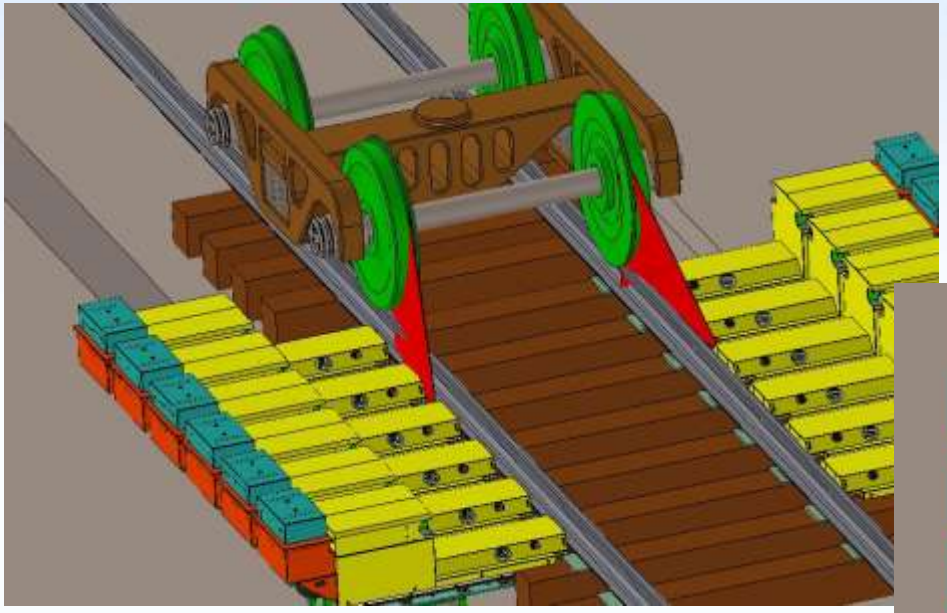
Complete Wheel Tread Scanning

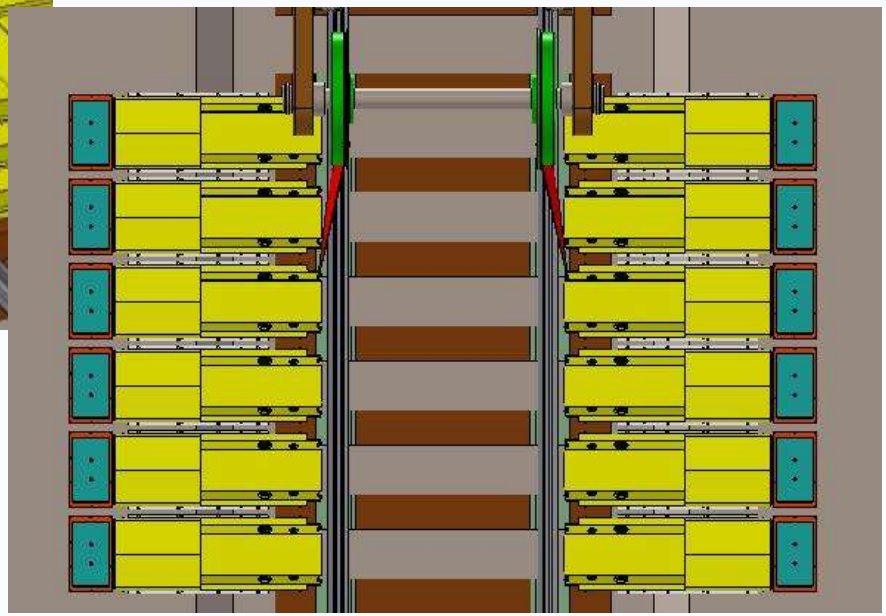
- Full Wheel Optical Scanning
- Dense Wheel Surface Inspection
- Extremely High Data Rate
- Full Laser and Optical Inspection
- Full Track Train Speeds

Vision- System Capabilities

- Detect all visible wheel defects such as:
  - Built-Up Tread
  - Shelled Tread
  - Grooved Tread
  - Slid Flat
  - Pieces missing from wheel
  - Visible cracks or breaks in the wheel tread/flange
- Profile Parameters (Optional)
  - Hollow Tread (deepest)
  - High Flange (at highest point)
  - Thin Rim (at thinnest point)
  - Thin Flange (at thinnest point)
- Based on AAR Tolerances

System Operation

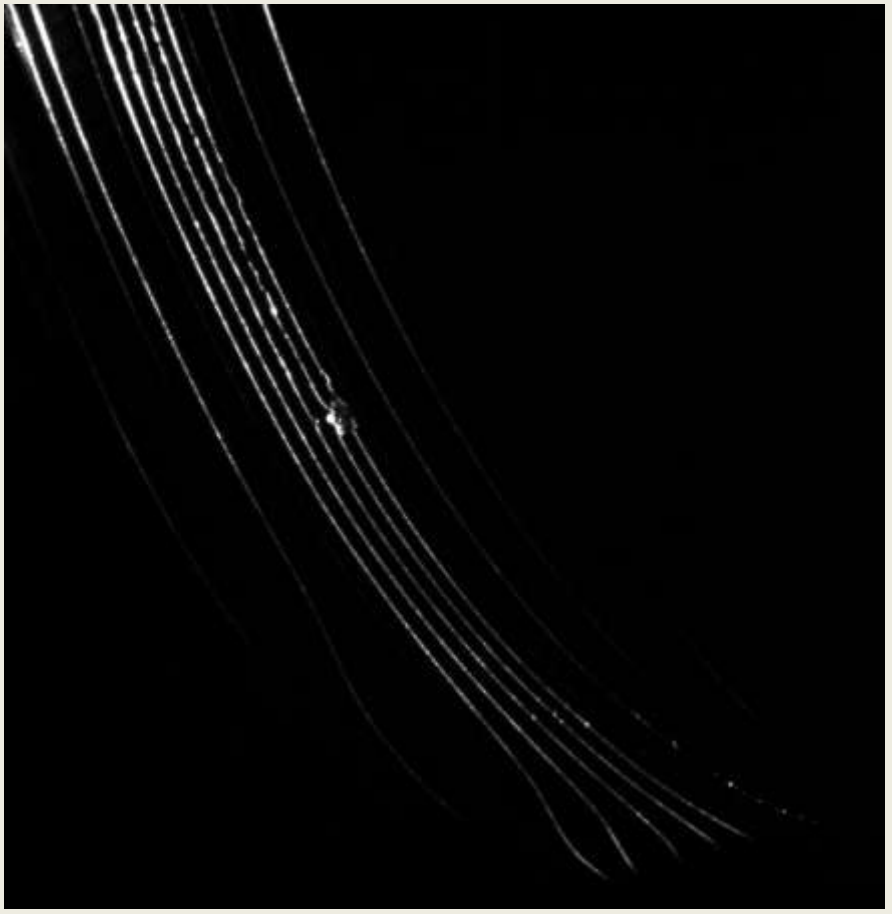




Tread Scan

Tread Scan

Tread Scan



Tread Scan

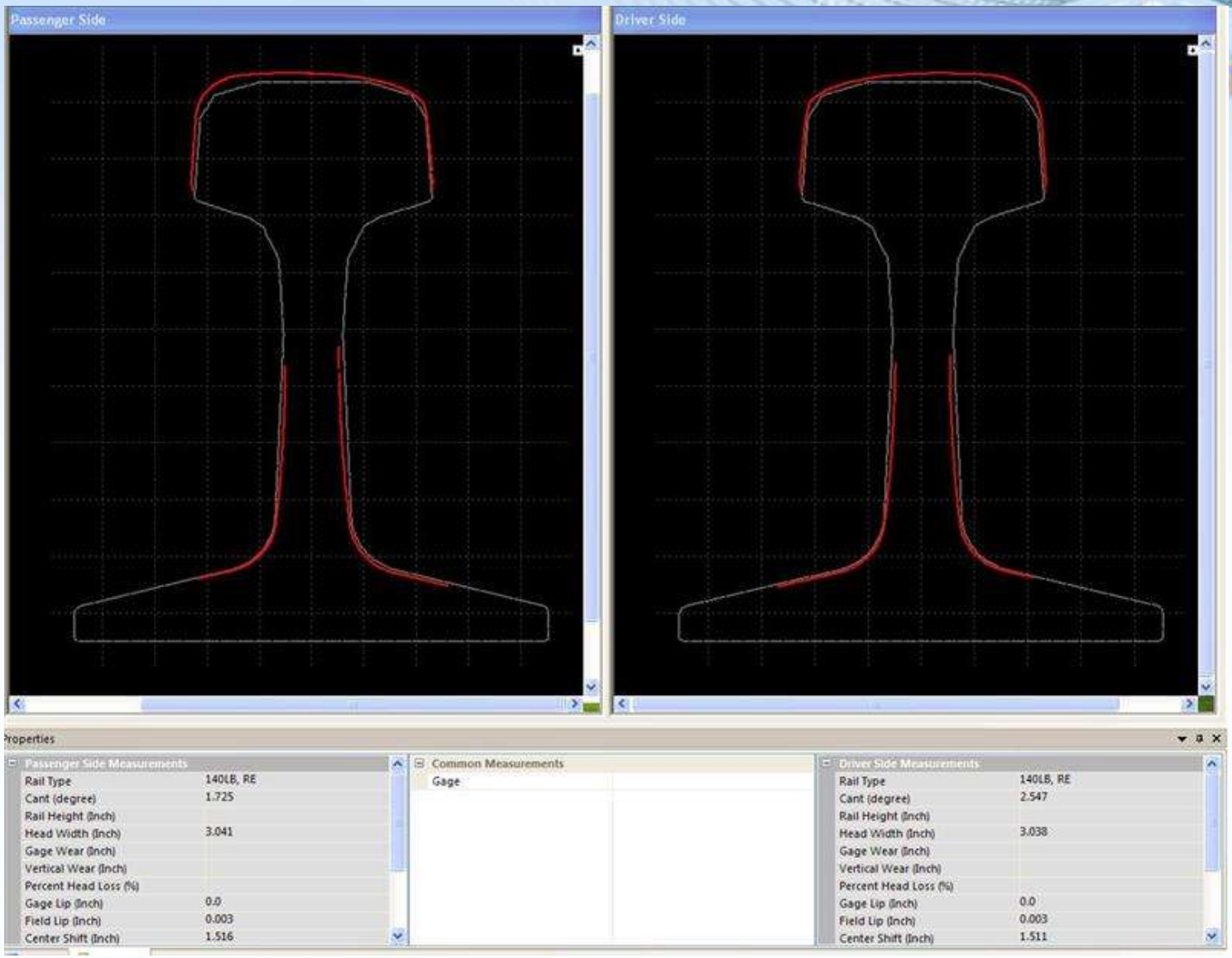
Rail Profile and Gauge Measurement Systems

BeenaVision

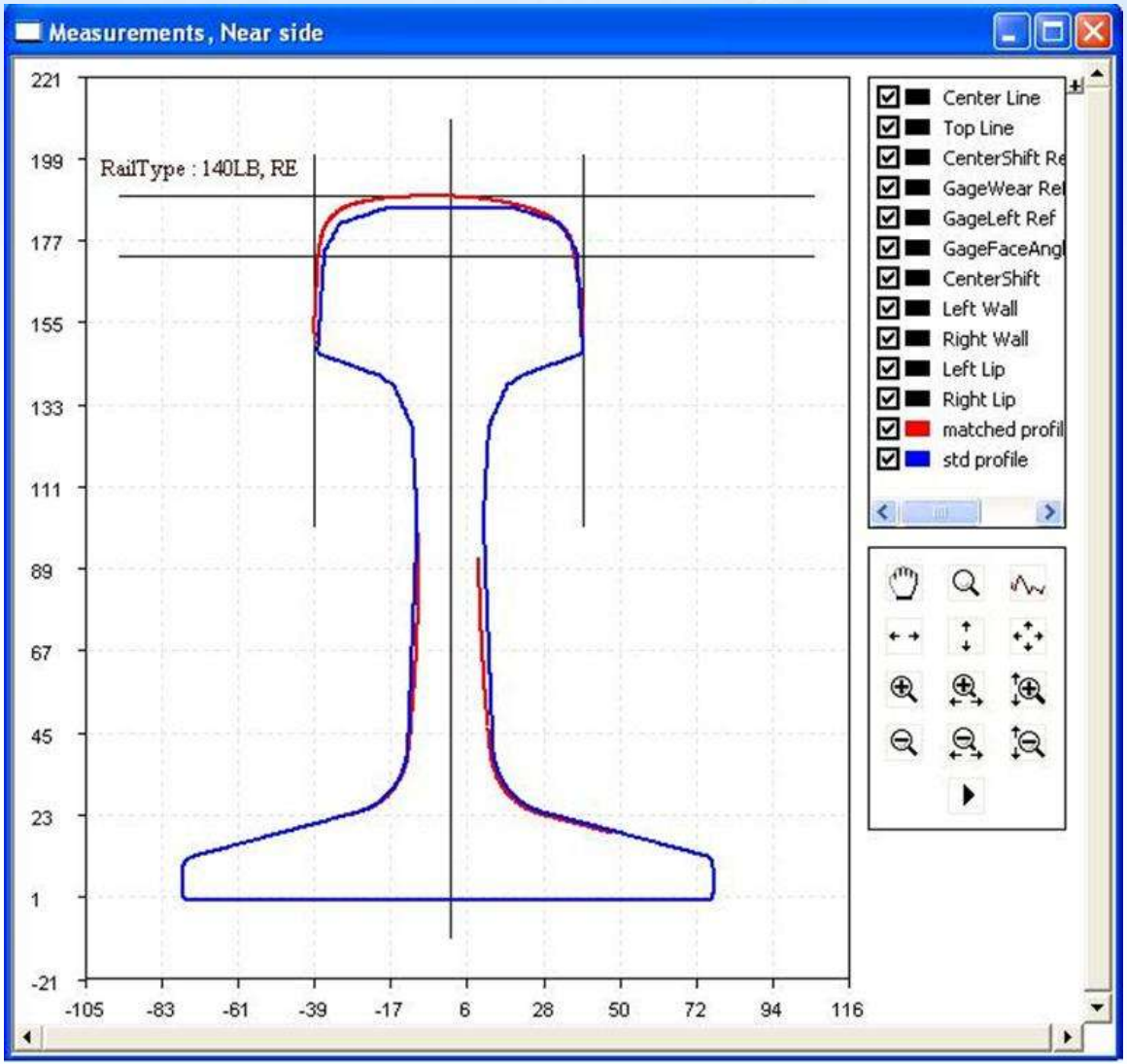
Track-Profile

- Laser Based Rail Profile measurement
  - Adjustable Profile Rate
    - 1 profile per foot at 45 mph with 60fps cameras
    - Up to 120 fps in standard version, 480fps in HS version
  - 1024 points per profile
  - Ambient light insensitive (High power laser)
  - Custom integration into customer systems
  - Flexible design for different vehicle installations
  - Real Time Profile Generation

Vehicle Mounting


Passenger Side
Driver Side
Properties
Passenger Side Measurements
Rail Type 140LB, RE
Cant (degree) 1.725
Rail Height (Inch)
Head Width (Inch) 3.041
Gage Wear (Inch)
Vertical Wear (Inch)
Percent Head Loss (%)
Gage Lip (Inch) 0.0
Field Lip (Inch) 0.003
Center Shift (Inch) 1.516
Common Measurements
Gage
Driver Side Measurements
Rail Type 140LB, RE
Cant (degree) 2.547
Rail Height (Inch)
Head Width (Inch) 3.038
Gage Wear (Inch)
Vertical Wear (Inch)
Percent Head Loss (%)
Gage Lip (Inch) 0.0
Field Lip (Inch) 0.003
Center Shift (Inch) 1.511

Measurements



Measurements

- Rail Cant
- Track Gage
- Rail Height
- Head Width
- Gage Lip
- Field Lip
- Vertical Wear
- 45 Degree Wear
- Head Loss Percent
- Gauge Face Width
- Rail Center Position
- Matching Rail Type or Weight

Track-Rail

Track and Rail Imaging and Inspection Systems

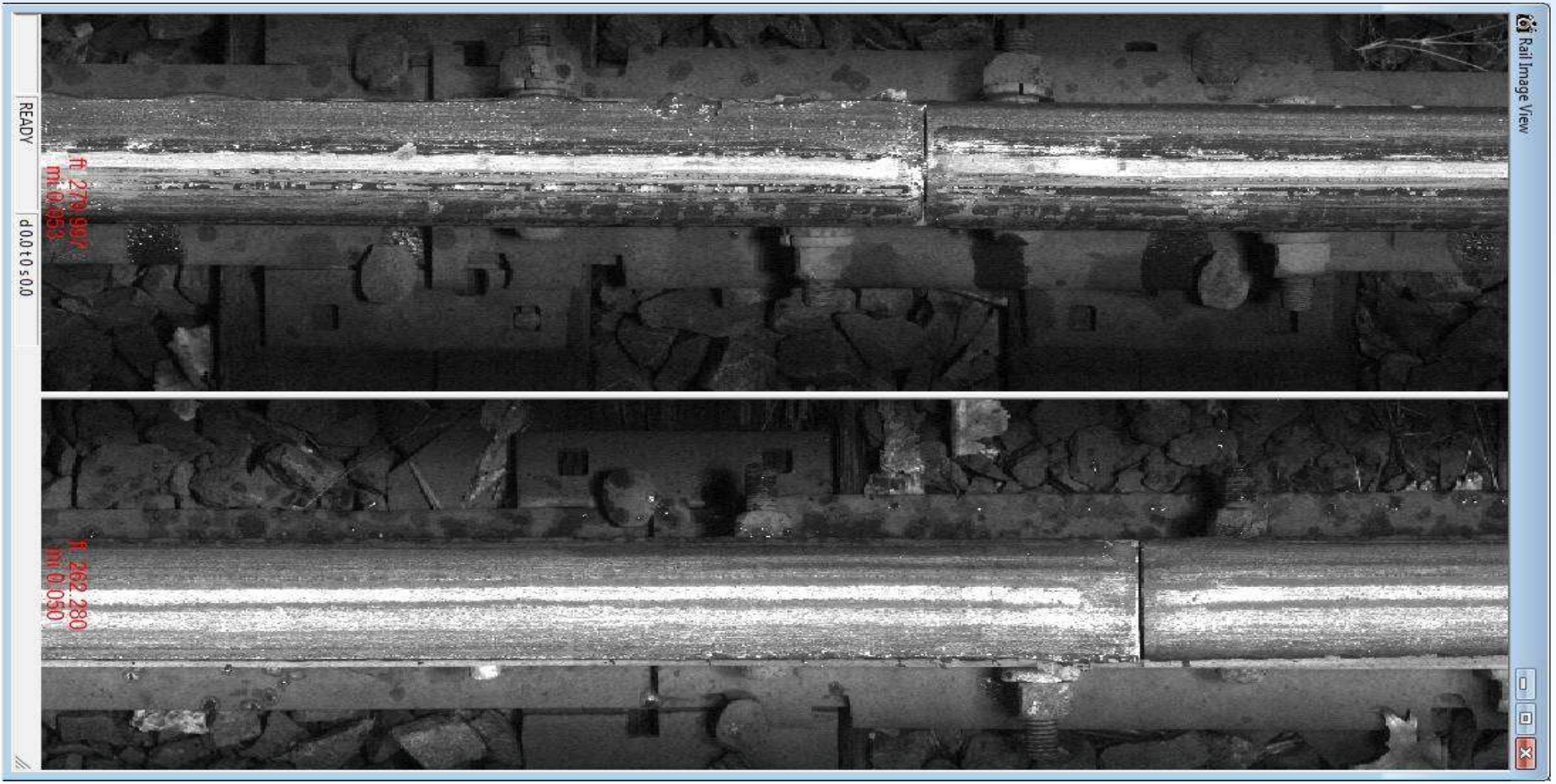
BeenaVision

Hi-Rail Truck Installation

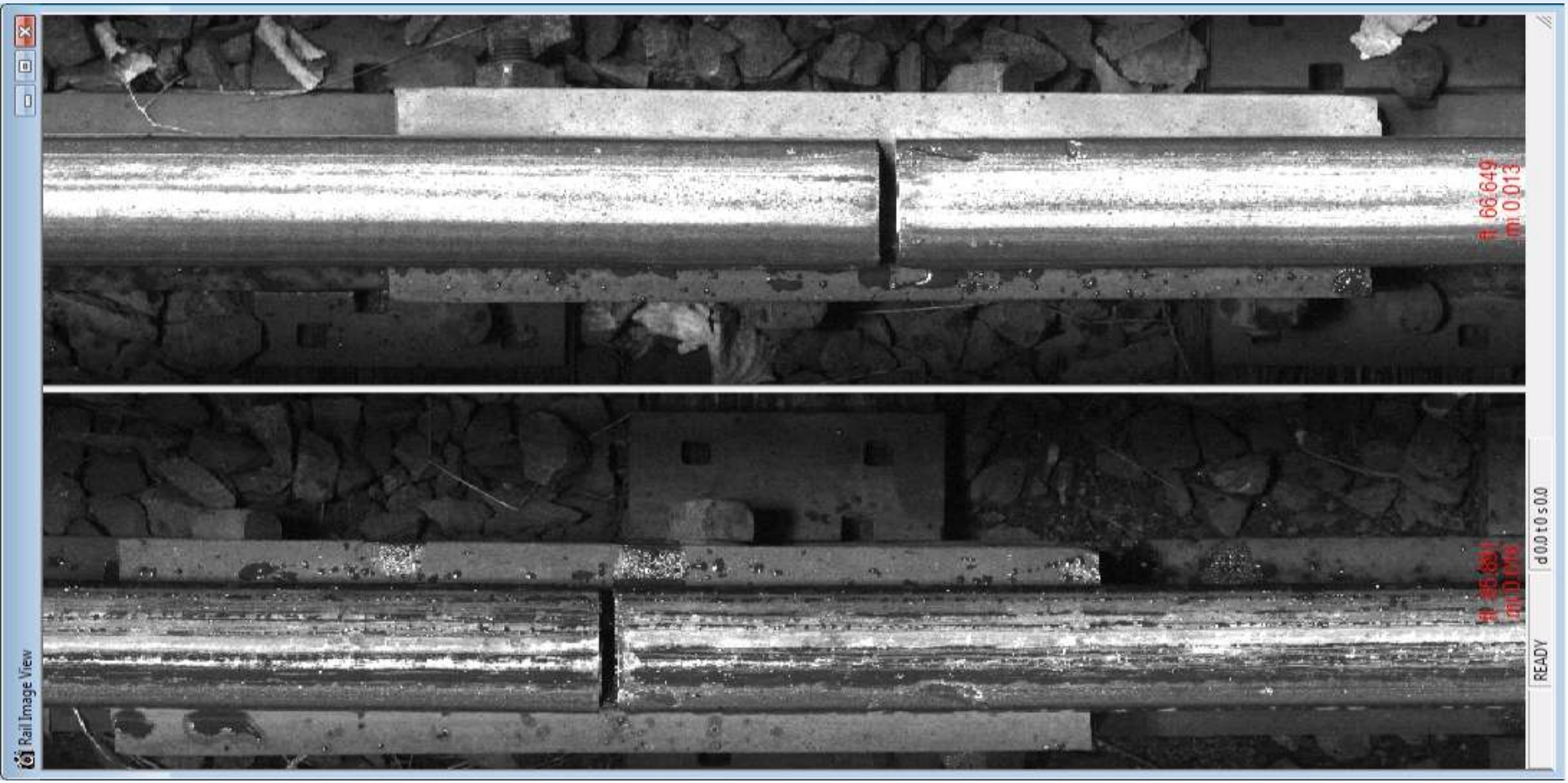
Rail and Track Imaging

- Line Scan Technology
- Infrared and Visible Spectrums Covered
- High Image Quality
- Rail Top View
- Rail Side View
- Track Structure such as spikes, tie plates, ties, etc.

Rail Surface Images



Rail-top Camera Images



System Features

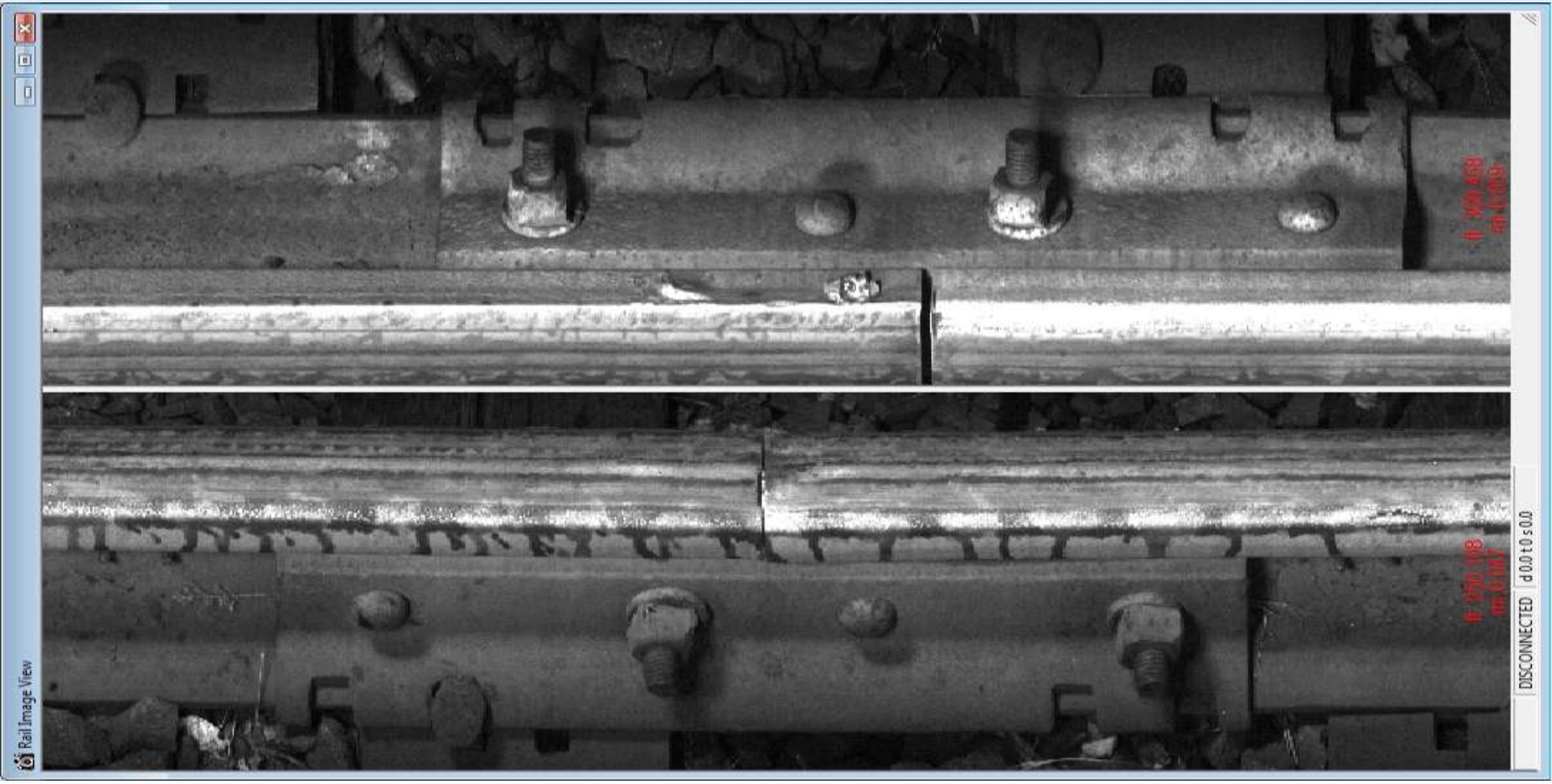
- Multiple cameras (up to nine cameras)
  - Rail top
  - Rail web
  - Rail base
  - Ties
  - Fasteners
- High Speed line scan technology
- IR or Visible Lighting

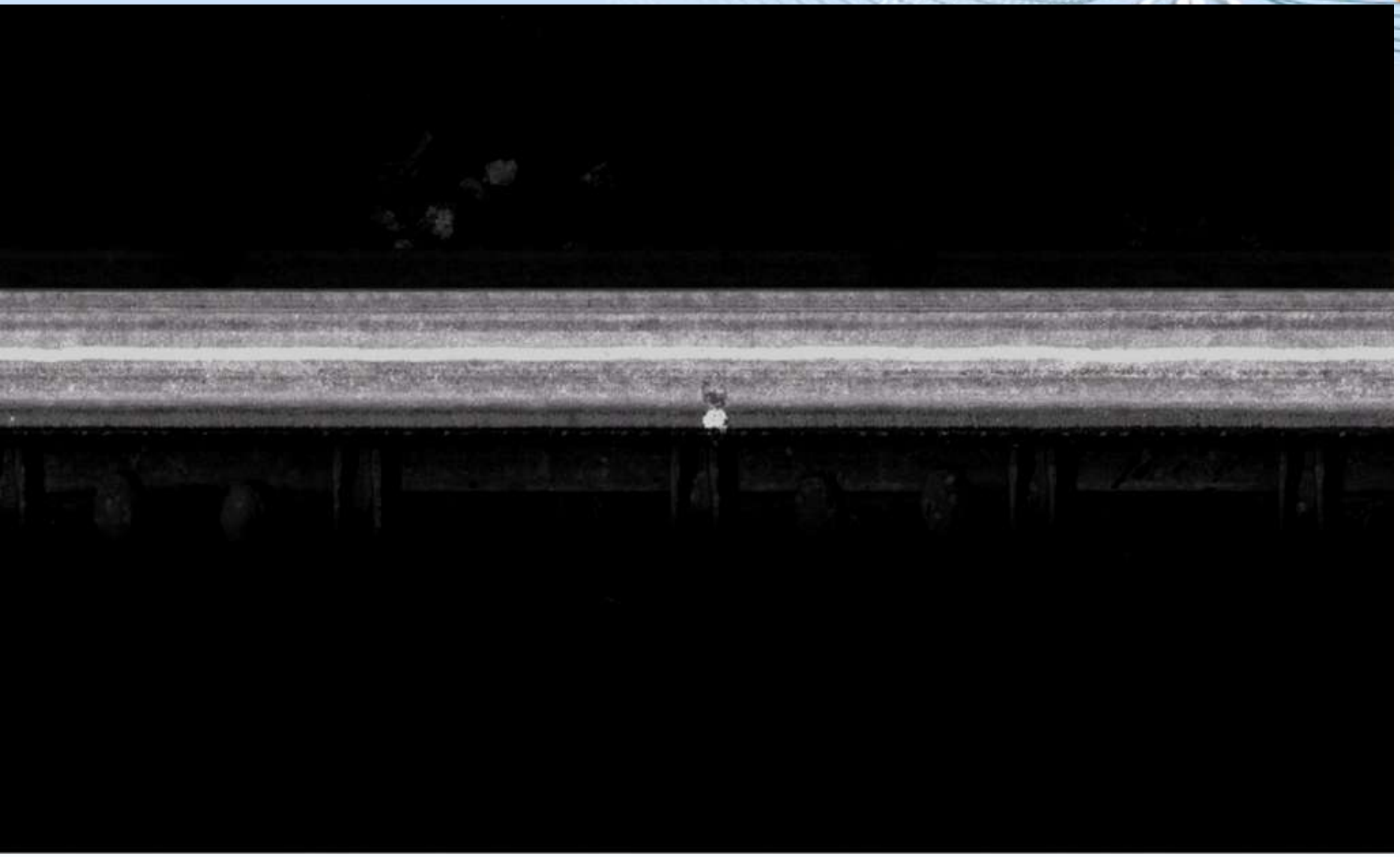
Applications

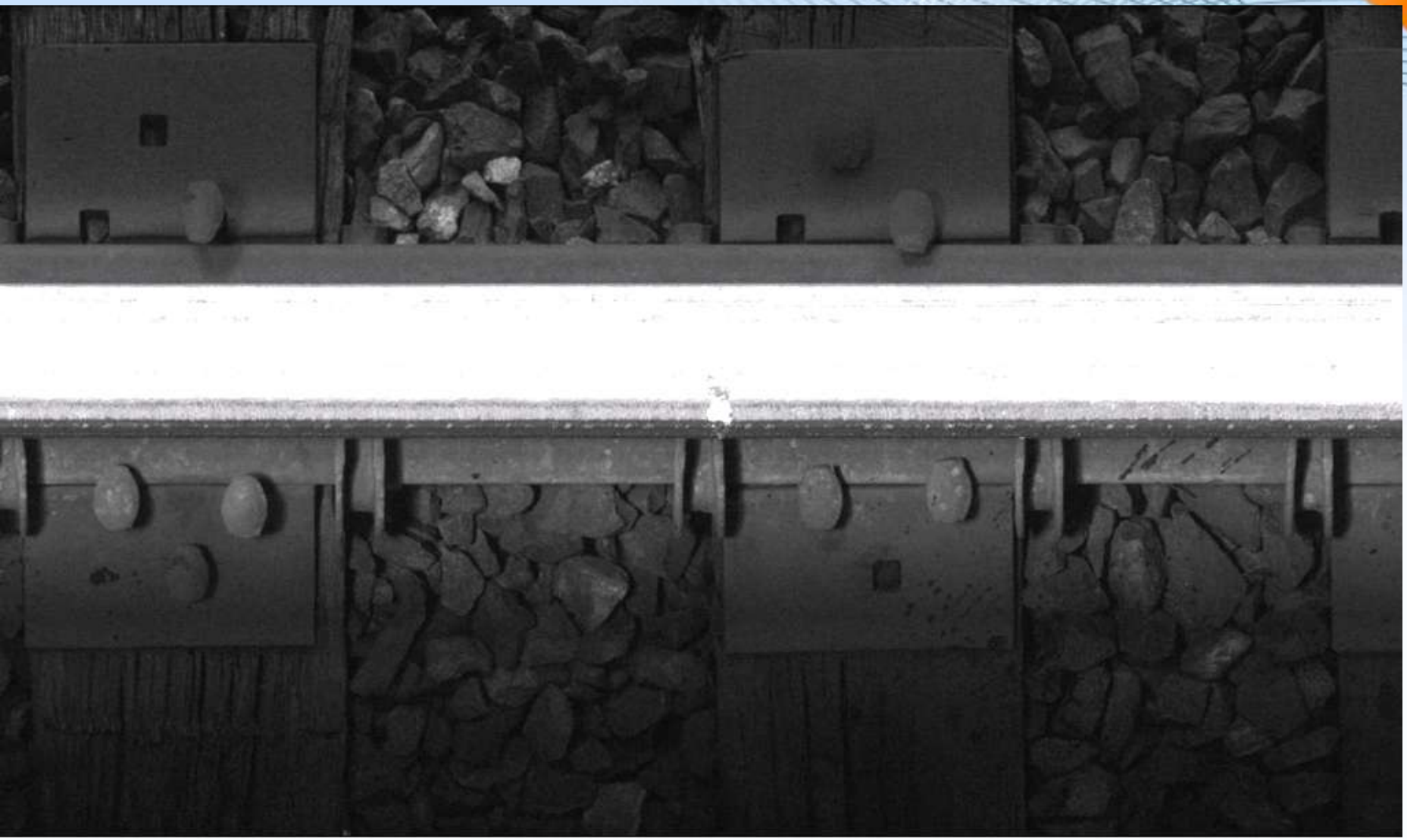
- Rail Surface Evaluation
- Joint Counting
- Joint Evaluations
- Rail Weight Recognition
- Track Inspection (ballast condition, vegetation)
- Tie Inspection
- Fastener Inspection

Lighting (Visible & IR)

Side Angled Camera Images







Vision Systems

- Innovative Solutions for Railroad Industry
- Laser Based Profile measurement Systems
- Image Based Inspections Systems


The End