Machine Vision and Strip Chart Assessment of Rolling Contact Fatigue

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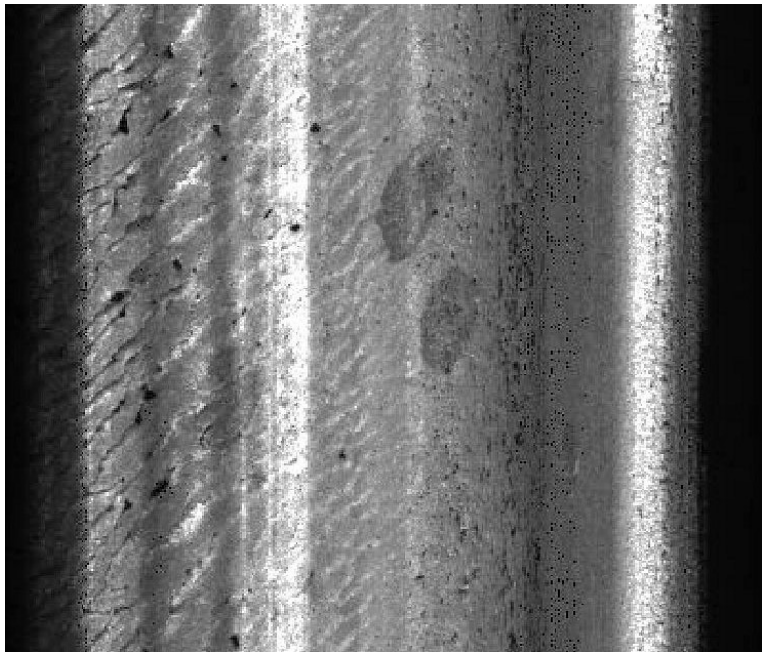
Background

- **Machine Vision** technology is growing in the rail industry.
- **Line Scan Cameras** are used to capture high resolution images of surfaces, such as the rail surface.
- This presentation discusses a process to convert the captured images into **strip chart data** to be viewed alongside track geometry and rail profile data**.**

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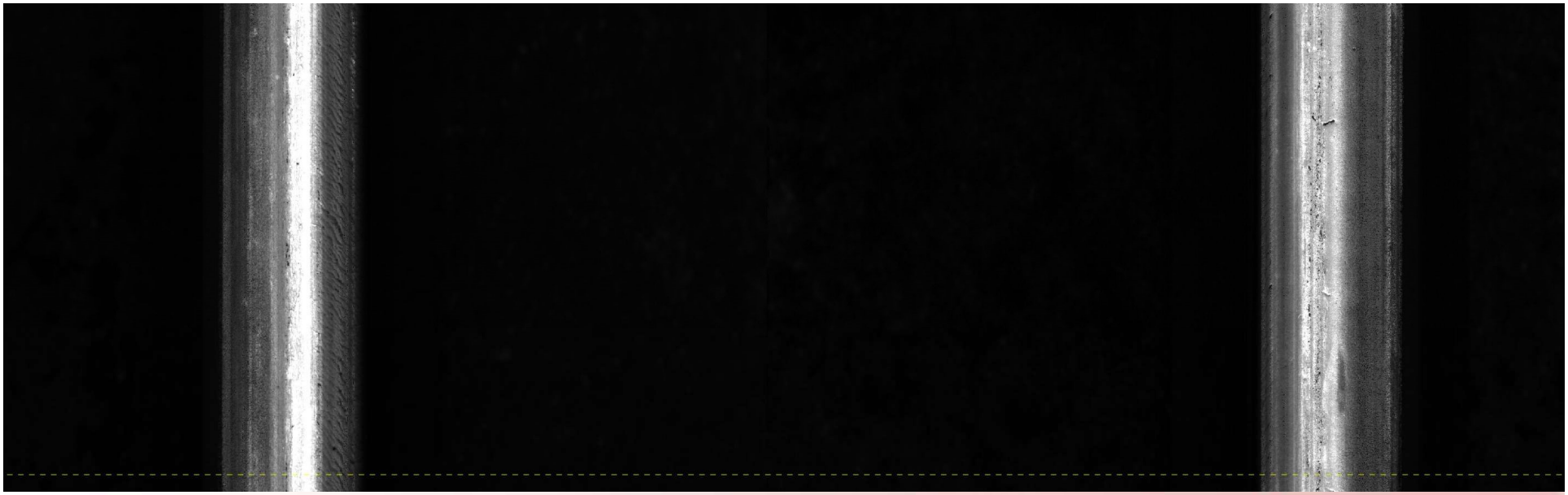
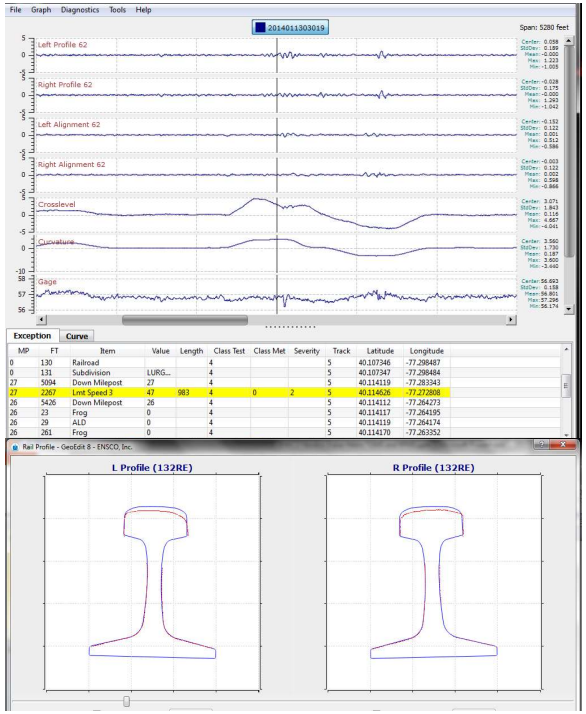
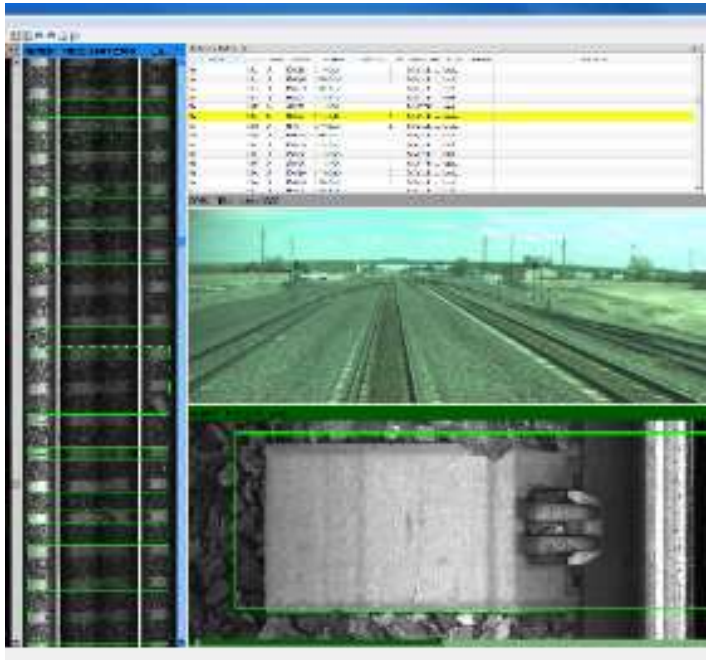
- Two cameras positioned to view the running rails including the gage face of the rails.
- Minimum resolution of 0.4mm at 65 mph. Can achieve higher speeds at lower resolution.



GeoEdit 8
Track Geometry and Rail Profile

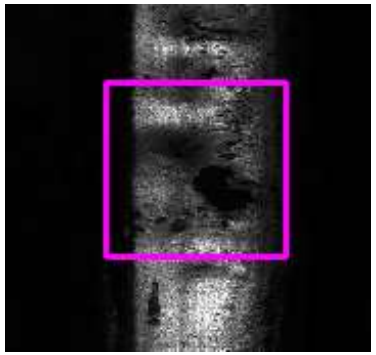


Virtual Track Walk (VTW)
Machine Vision Imagery



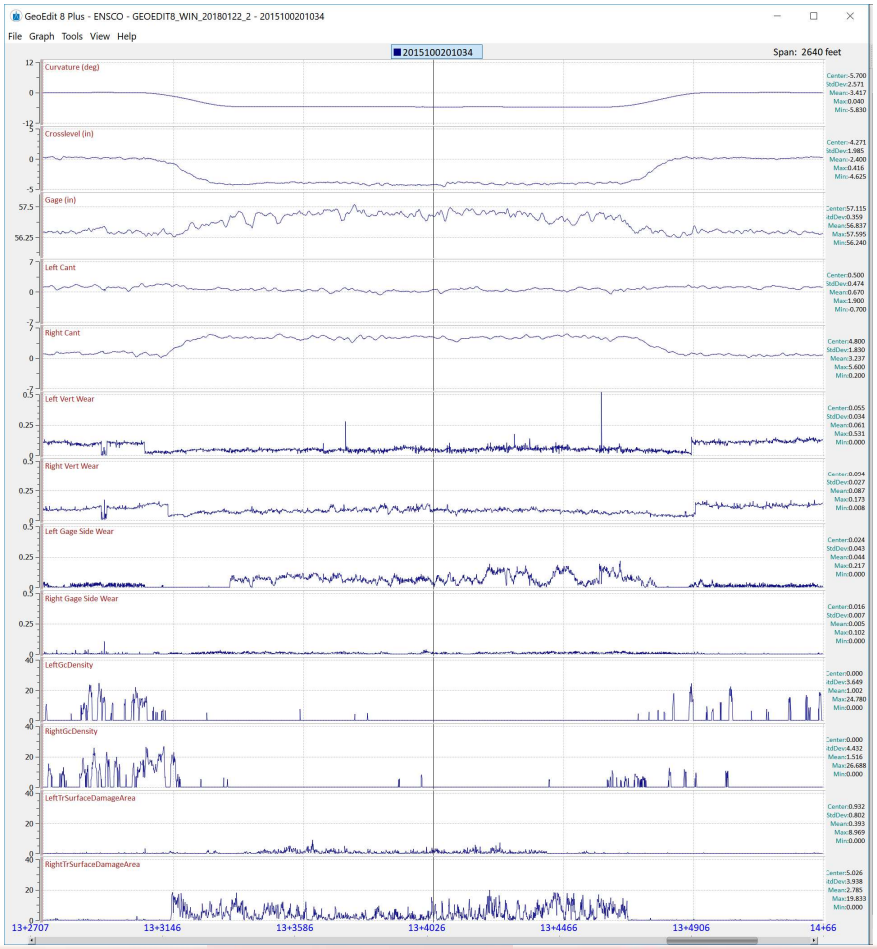
Background: Defect Detection

- Traditionally machine vision algorithms look for distinct defects.
- These defects are reported individually and are intended to be repaired individually.
- In the case of rail surface, this process works well for detecting broken rail, engine burns etc…
- However, to use this approach for RCF and other surface damage quantification, it creates data overload.



Where we want to be:

Rail Surface Condition Strip Charts



Step 1: Grinding Detection

- Heavy grinding marks are important to identify so that they don't interfere with the machine vision calculations.
- An algorithm was developed to determine if the rail surface has been ground or not ground.
- If the surface was determined to be ground, the band segment calculations are adjusted.

Curvature (deg)

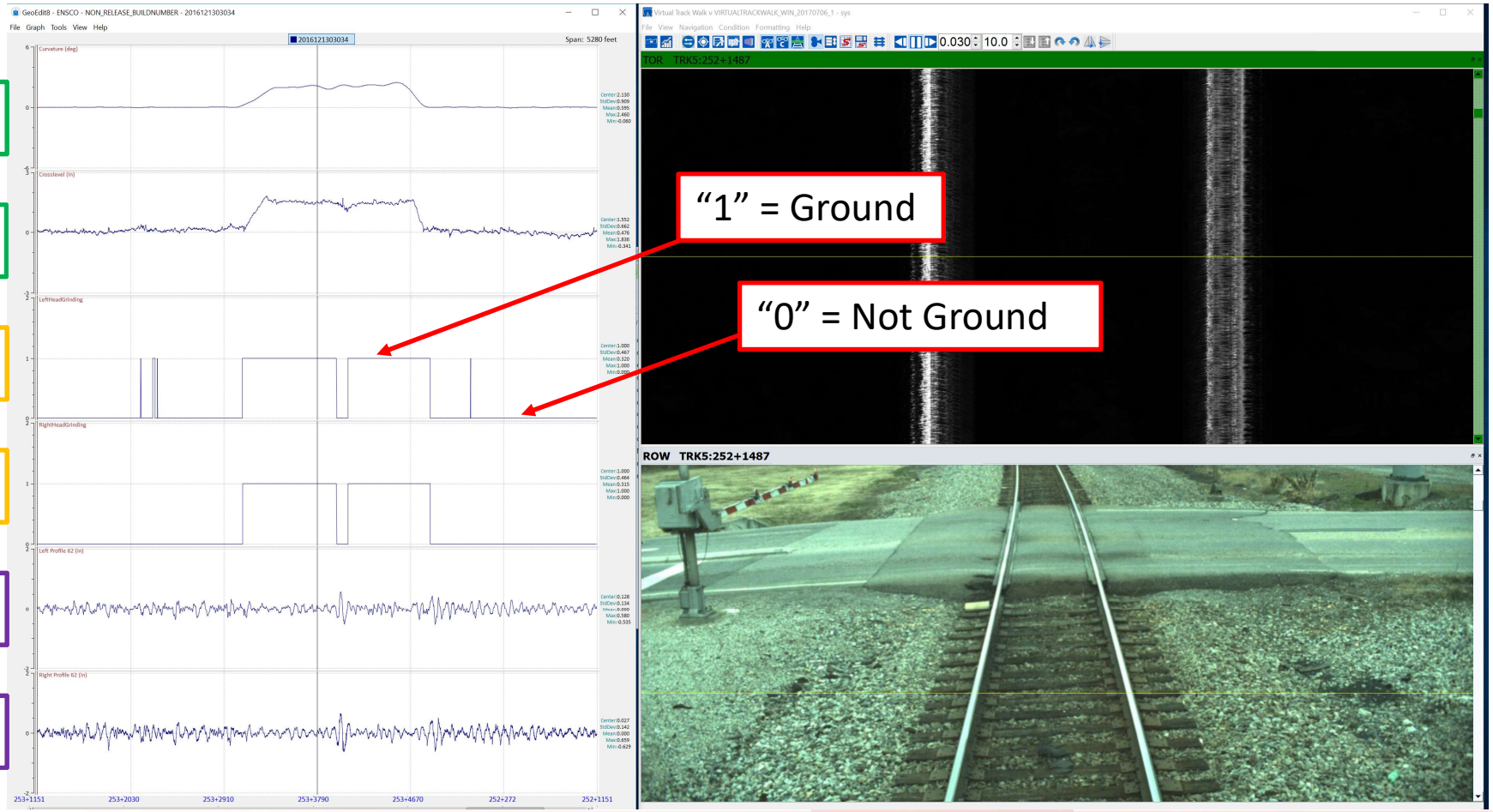
Crosslevel (in)

L Rail Grinding

R Rail Grinding

L Rail 62’ Profile (in)

R Rail 62’ Profile (in)



Curvature (deg)

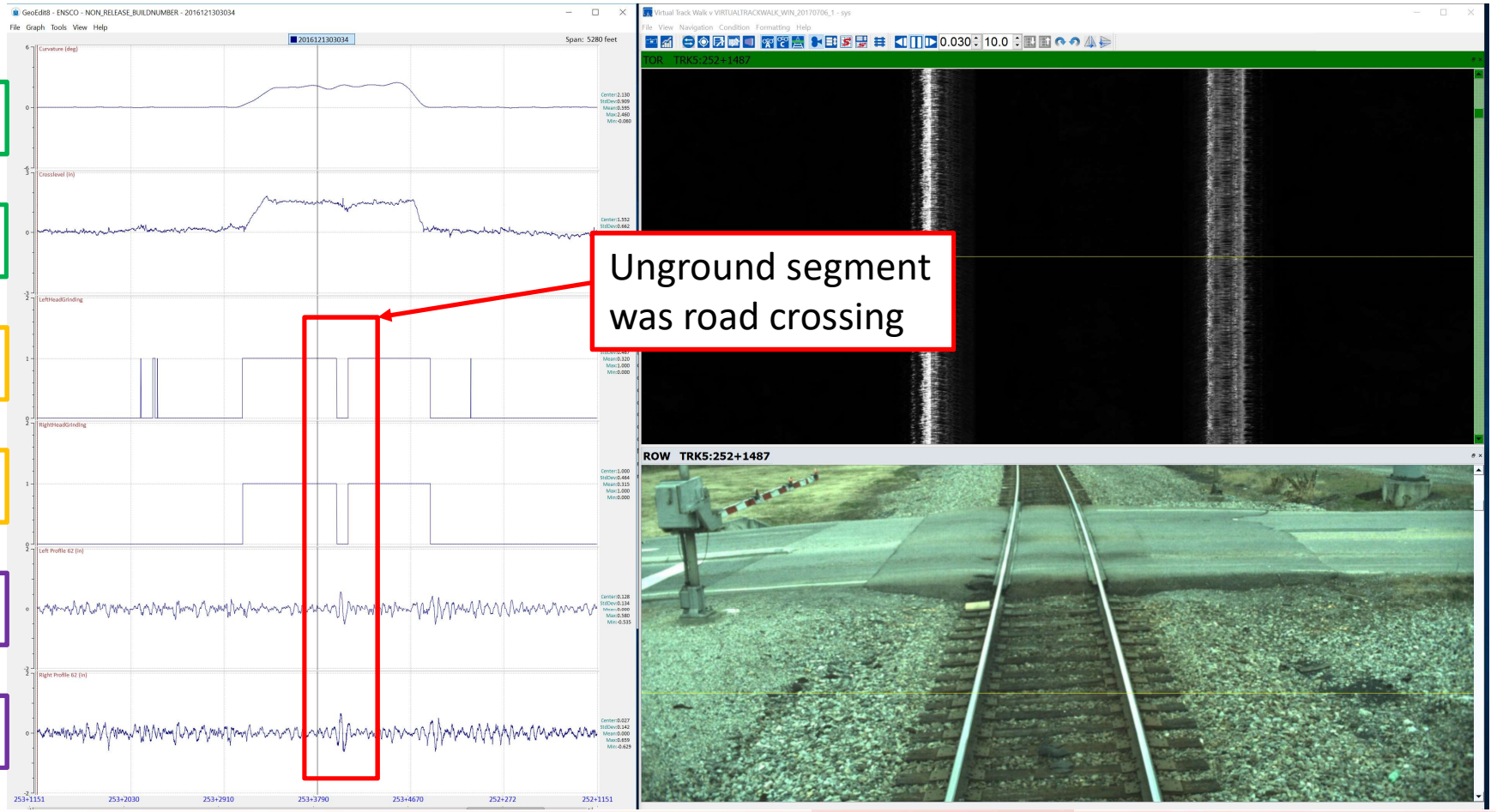
Crosslevel (in)

L Rail Grinding

R Rail Grinding

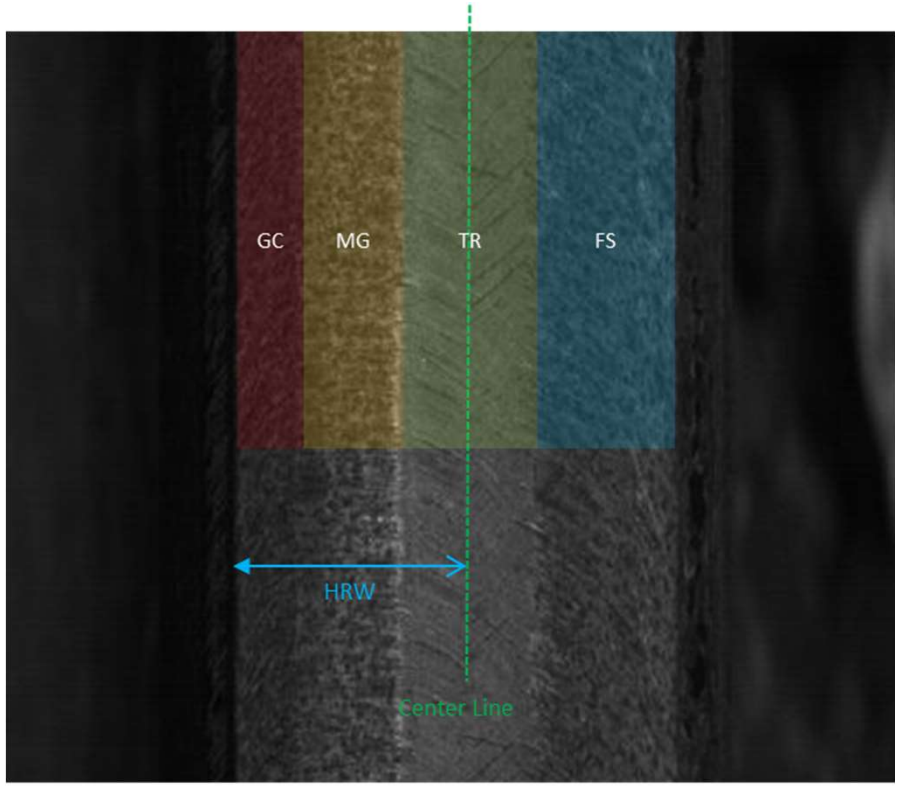
L Rail 62’ Profile (in)

R Rail 62’ Profile (in)



Step 2: Rail Surface Bands

- Rail head is split into four bands.
- Band width is adjustable
- Each band is 1-foot (250mm) in length
- A fifth band is included of the full rail width
- **5 rail surface bands total.**



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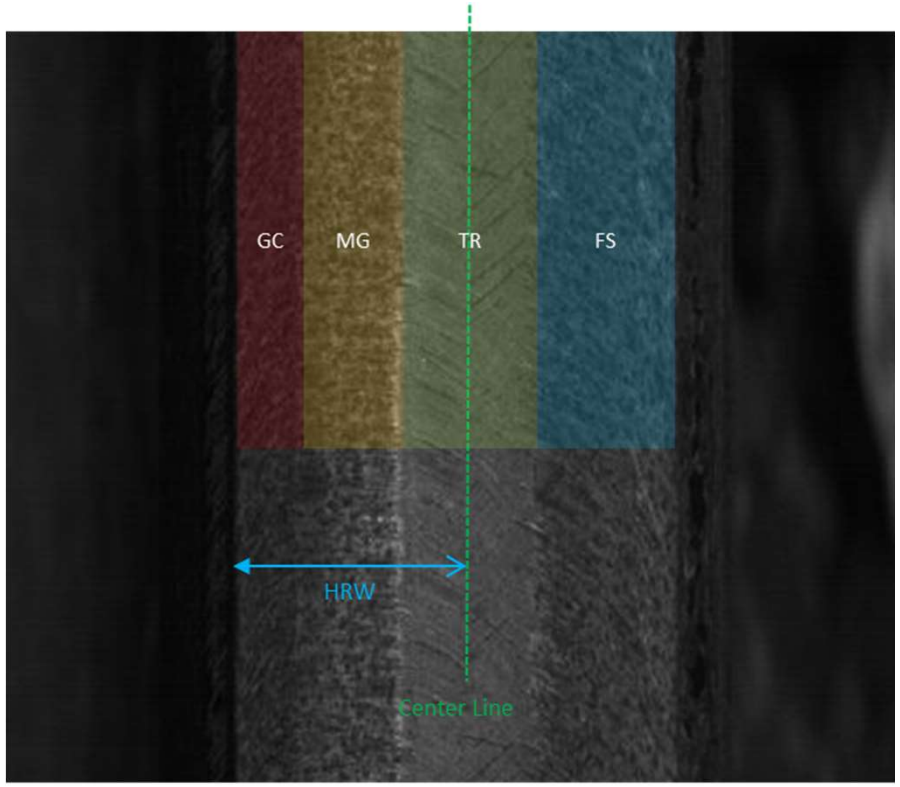
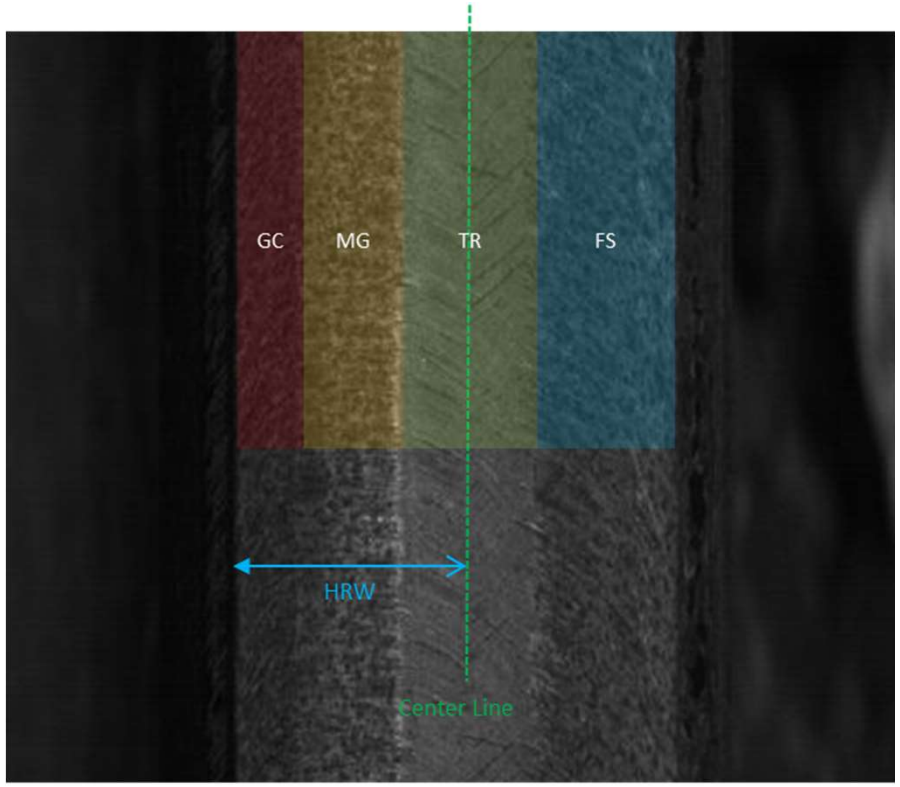


Step 2: Rail Surface Bands

- **5 rail surface bands per rail.**
- **5 calculated values per band.**
- **2 rails**
- **5x5x2 = 50 strip chart channels**



Curvature (deg)

Crosslevel (in)

Gage (in)

L Cant (deg)

R Cant (deg)

L GF Crack Density

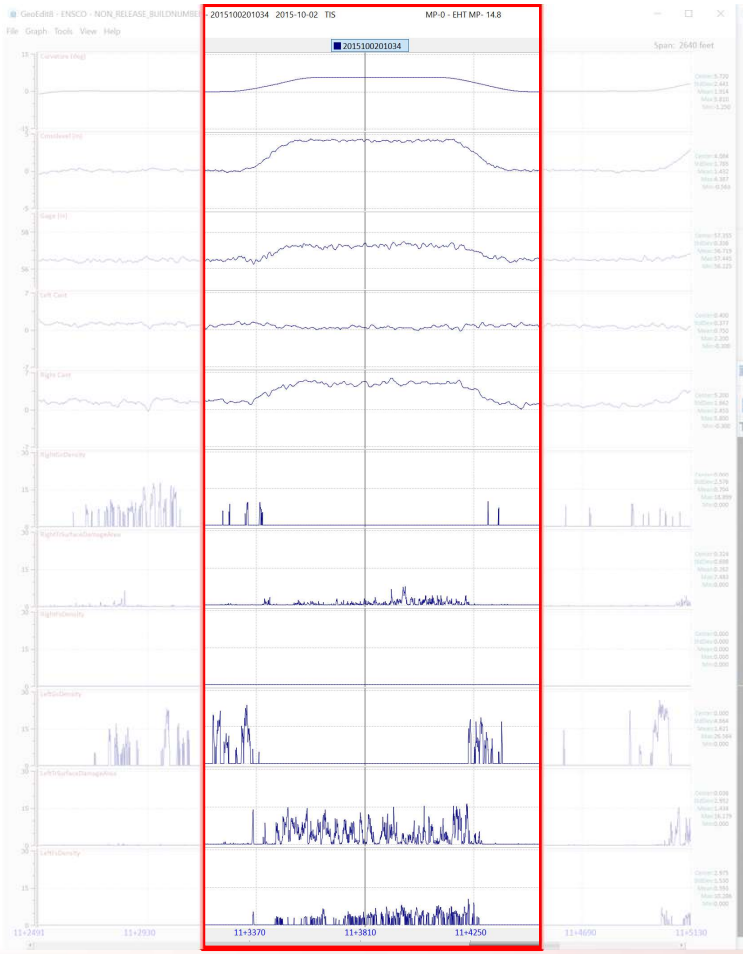
L TOR Damage Area

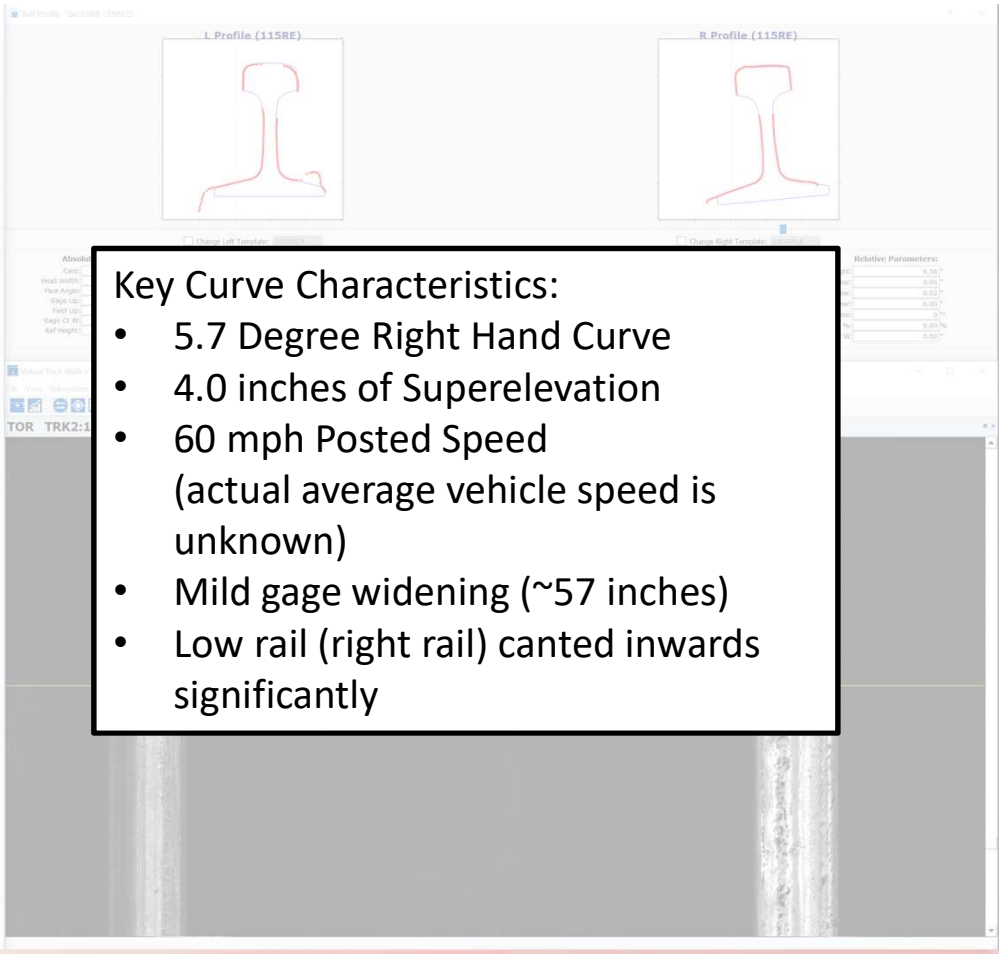
L FS Crack Density

R GF Crack Density

R TOR Damage Area

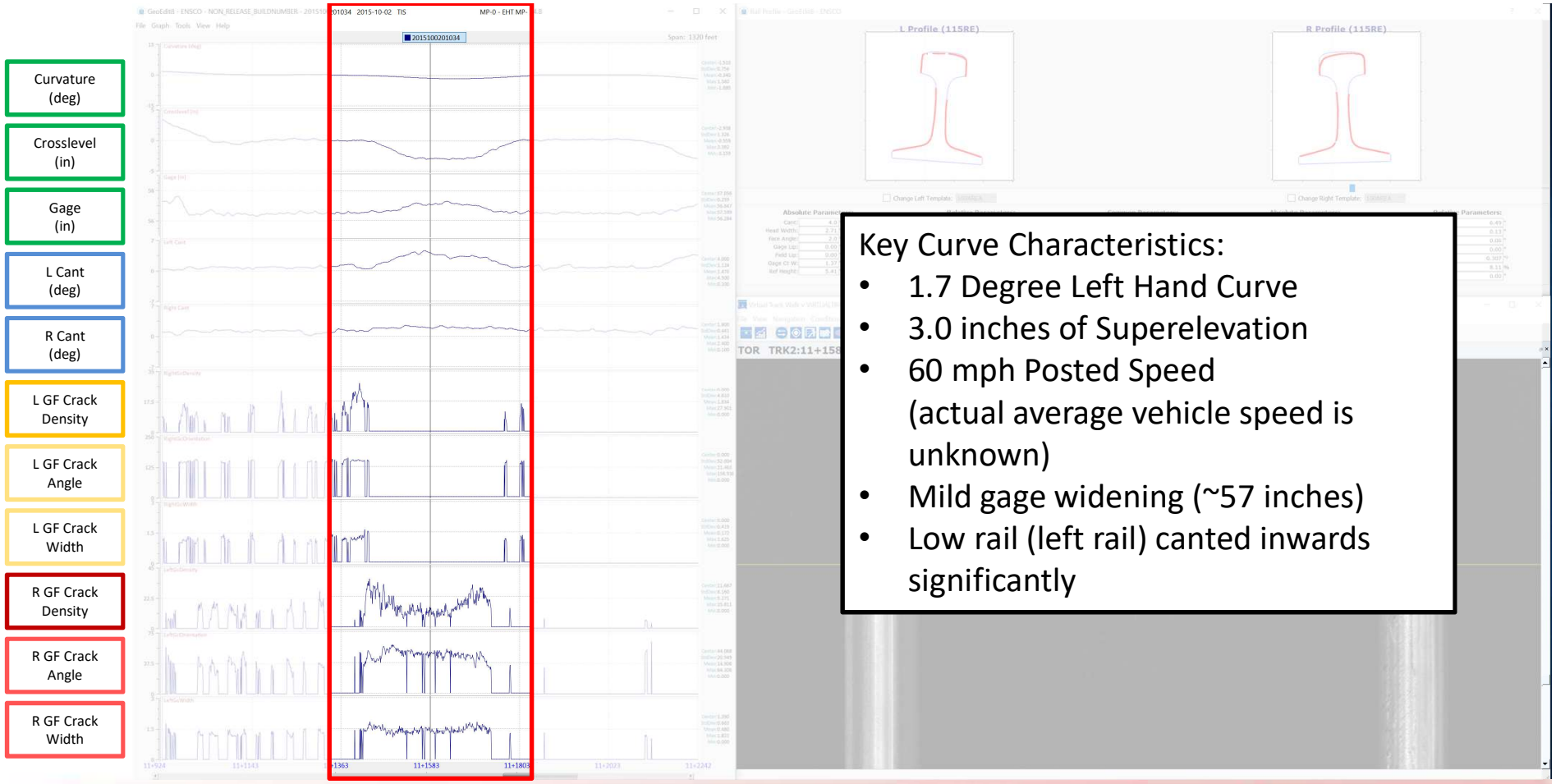
R FS Crack Density





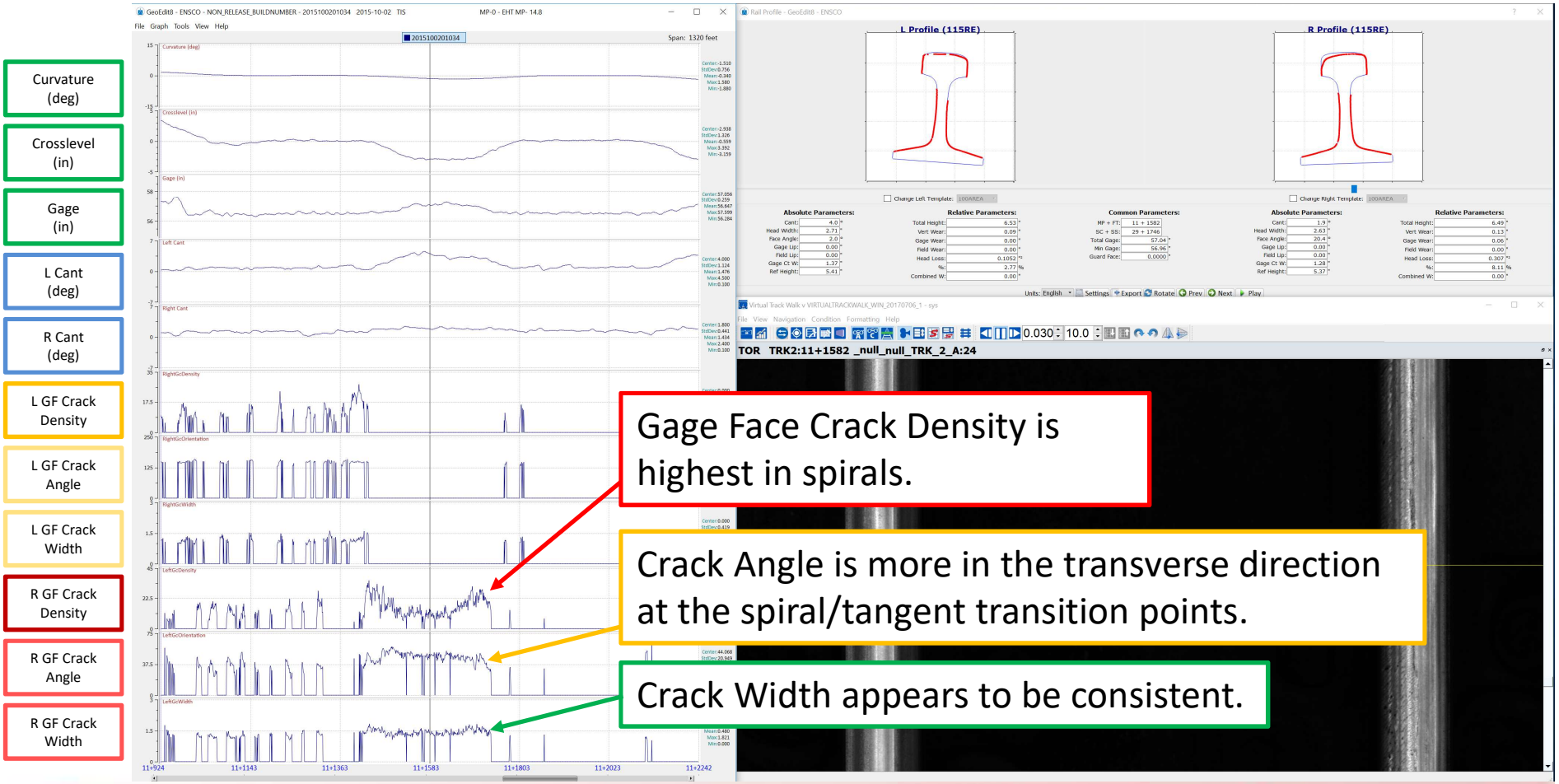
Key Curve Characteristics:

- 5.7 Degree Right Hand Curve
- 4.0 inches of Superelevation
- 60 mph Posted Speed
  (actual average vehicle speed is unknown)
- Mild gage widening (~57 inches)
- Low rail (right rail) canted inwards significantly



Key Curve Characteristics:

- 1.7 Degree Left Hand Curve
- 3.0 inches of Superelevation
- 60 mph Posted Speed (actual average vehicle speed is unknown)
- Mild gage widening (~57 inches)
- Low rail (left rail) canted inwards significantly


Curvature (deg)
Crosslevel (in)
Gage (in)
L Cant (deg)
R Cant (deg)
L GF Crack Density
L GF Crack Angle
L GF Crack Width
R GF Crack Density
R GF Crack Angle
R GF Crack Width
L Profile (115RE)
R Profile (115RE)
TOR TRK2:11+1582 _null_null_TRK_2_A:24
Gage Face Crack Density is highest in spirals.
Crack Angle is more in the transverse direction at the spiral/tangent transition points.
Crack Width appears to be consistent.

Curvature (deg)

Crosslevel (in)

Gage (in)

L Cant (deg)

R Cant (deg)

L Vert Wear (in)

R Vert Wear (in)

L Gage Wear (in)

R Gage Wear (in)

L GF Crack Density

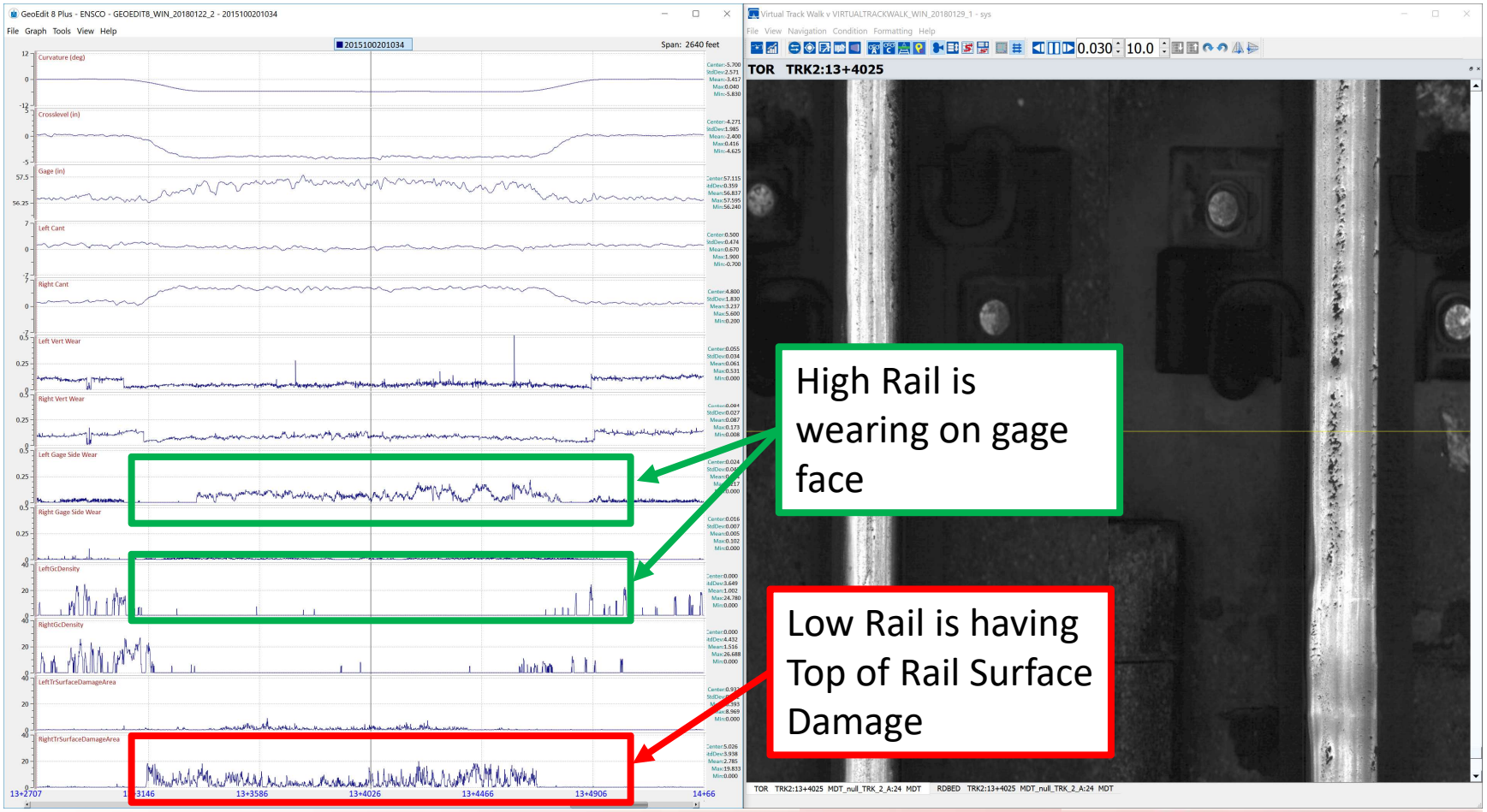
R GF Crack Density

L TOR Damage Area

R TOR Damage Area

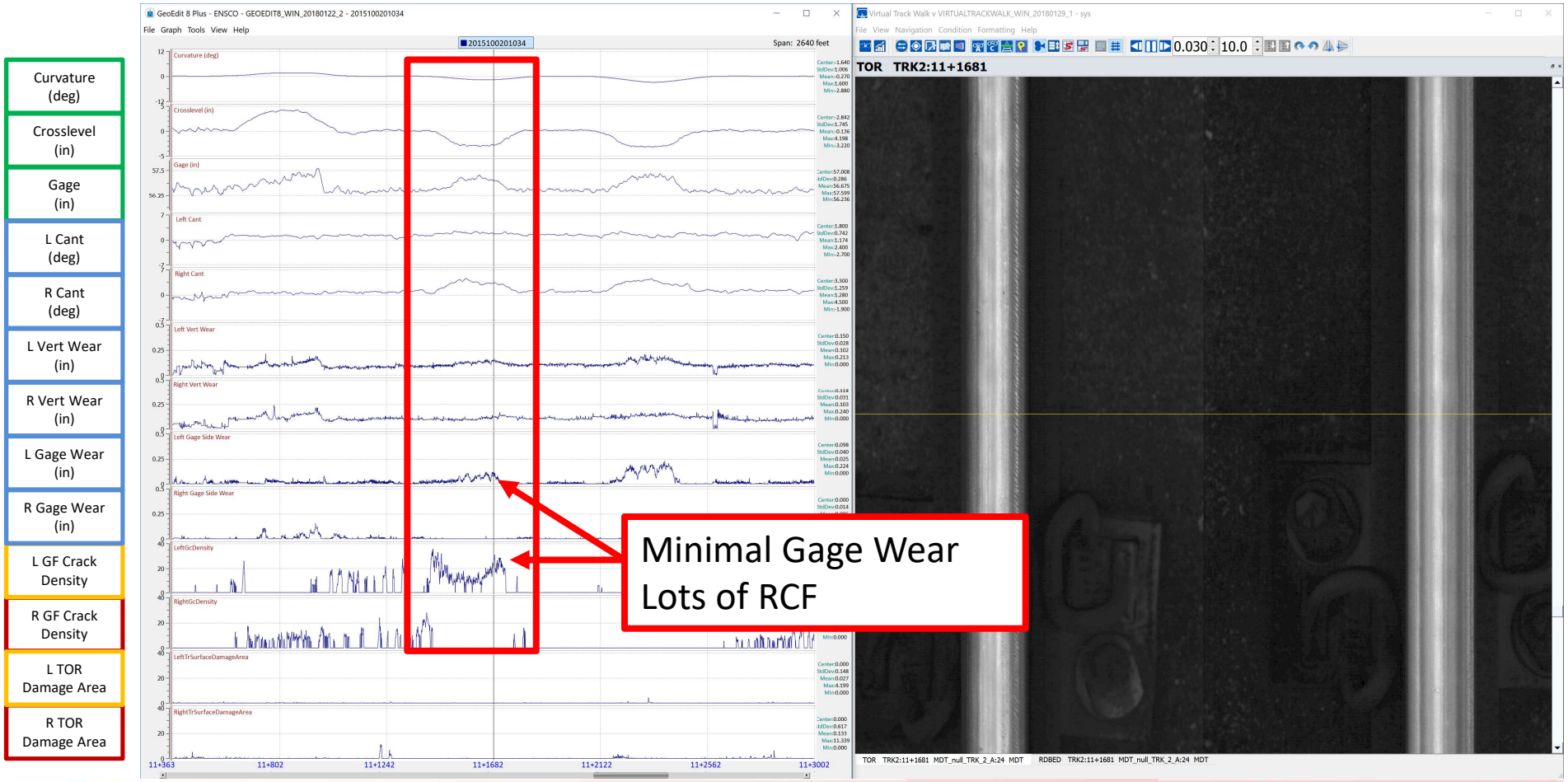
Rail replacement missed RCF on tangent

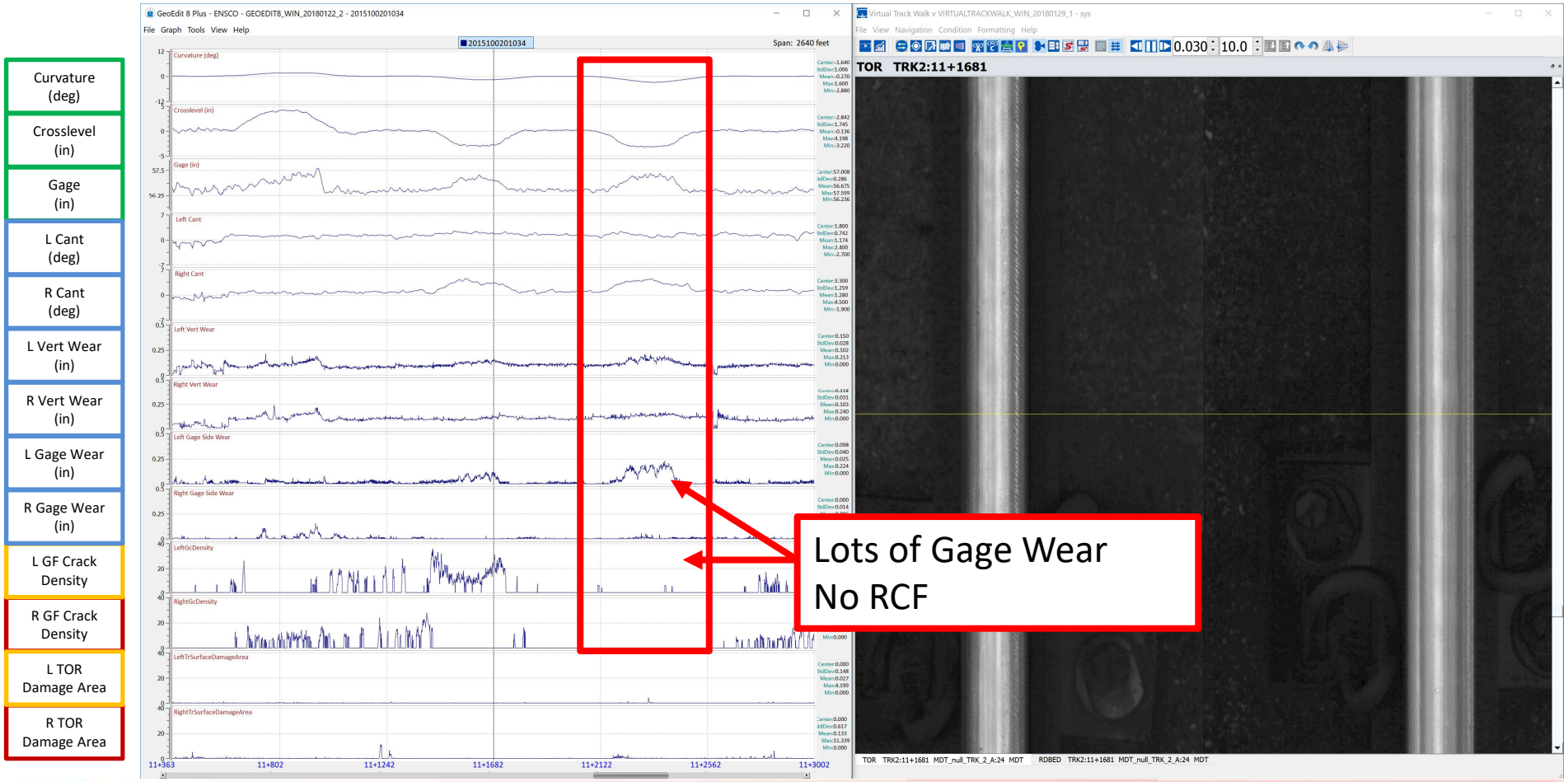
- Curvature (deg)
- Crosslevel (in)
- Gage (in)
- L Cant (deg)
- R Cant (deg)
- L Vert Wear (in)
- R Vert Wear (in)
- L Gage Wear (in)
- R Gage Wear (in)
- L GF Crack Density
- R GF Crack Density
- L TOR Damage Area
- R TOR Damage Area



High Rail is wearing on gage face

Low Rail is having Top of Rail Surface Damage


Curvature (deg)
Crosslevel (in)
Gage (in)
L Cant (deg)
R Cant (deg)
L Vert Wear (in)
R Vert Wear (in)
L Gage Wear (in)
R Gage Wear (in)
L GF Crack Density
R GF Crack Density
L TOR Damage Area
R TOR Damage Area
Minimal Gage Wear
Lots of RCF
TOR TRK2:11+1681


Curvature (deg)
Crosslevel (in)
Gage (in)
L Cant (deg)
R Cant (deg)
L Vert Wear (in)
R Vert Wear (in)
L Gage Wear (in)
R Gage Wear (in)
L GF Crack Density
R GF Crack Density
L TOR Damage Area
R TOR Damage Area
GeoEdit 8 Plus - ENSCO - GEOEDIT8_WIN_20180122_2 - 2015100201034
File Graph Tools View Help
2015100201034
Span: 2640 feet
Curvature (deg)
Crosslevel (in)
Gage (in)
Left Cant
Right Cant
Left Vert Wear
Right Vert Wear
Left Gage Side Wear
Right Gage Side Wear
LeftGcDensity
RightGcDensity
LeftTrSurfaceDamageArea
RightTrSurfaceDamageArea
11+363
11+802
11+1242
11+1682
11+2122
11+2562
11+3002
Virtual Track Walk v VIRTUALTRACKWALK_WIN_20180129_1 - sys
File View Navigation Condition Formatting Help
0.030
10.0
TOR TRK2:11+1681
TOR TRK2:11+1681 MDT_null_TRK_2_A:24 MDT
RDBED TRK2:11+1681 MDT_null_TRK_2_A:24 MDT
Lots of Gage Wear
No RCF

Curvature (deg)

Crosslevel (in)

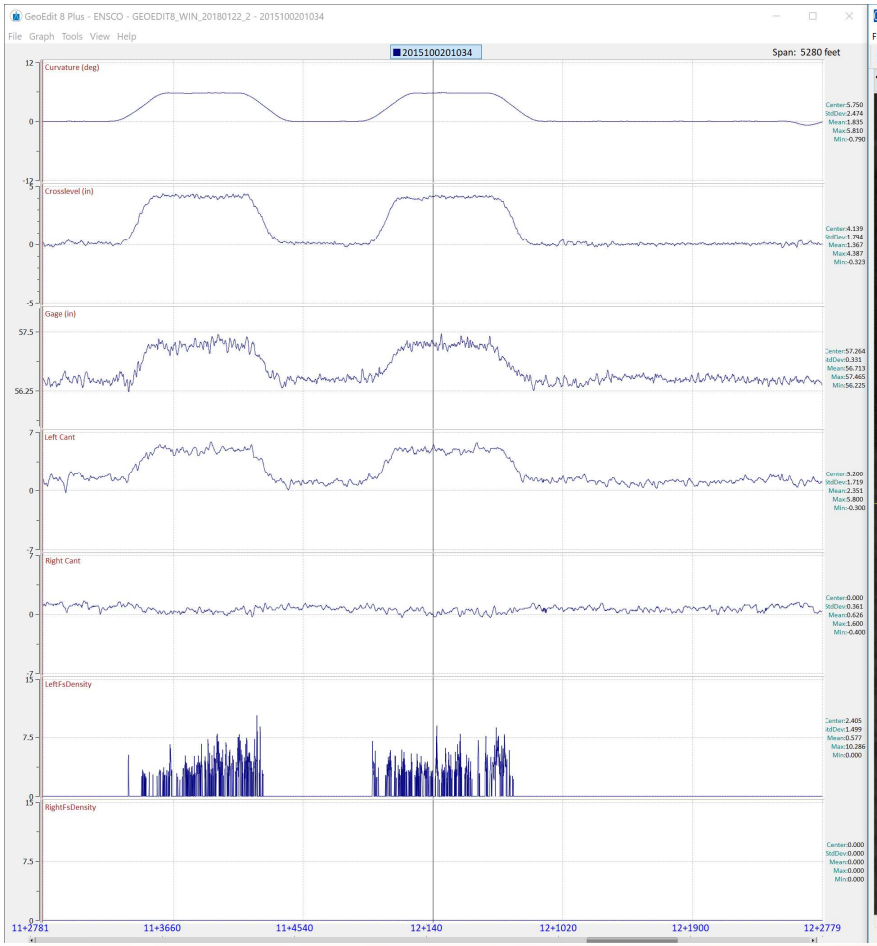
Gage (in)

L Cant (deg)

R Cant (deg)

L FS Crack Density

R FS Crack Density



Curvature (deg)

Crosslevel (in)

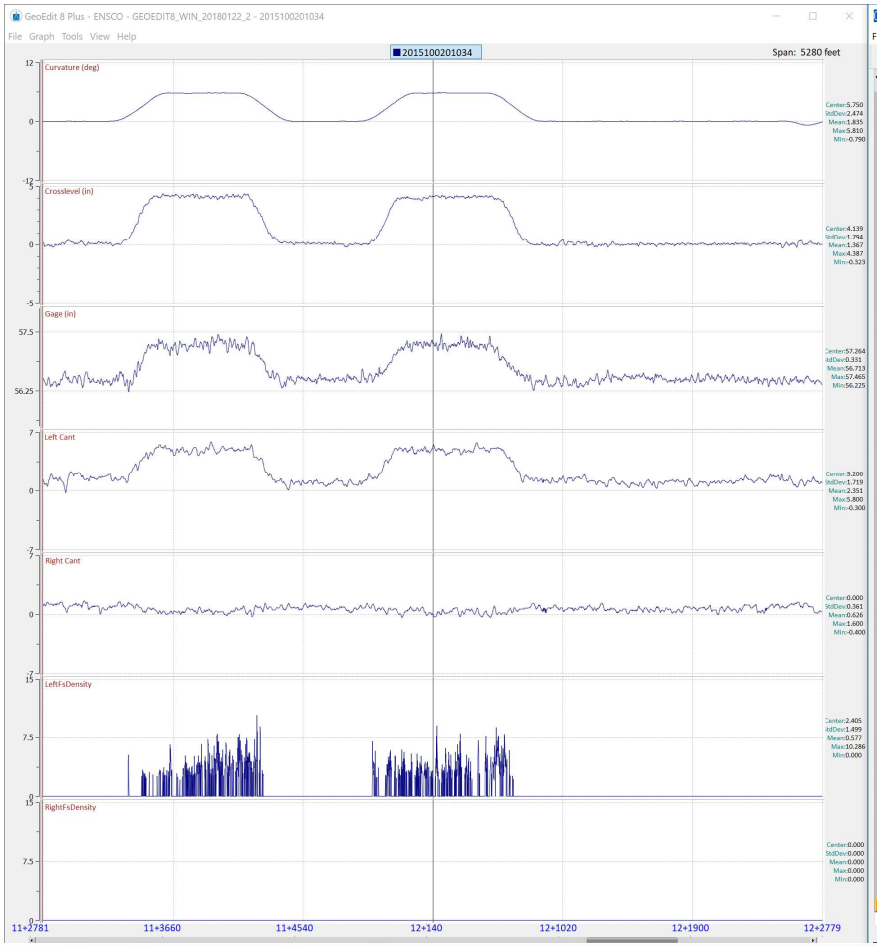
Gage (in)

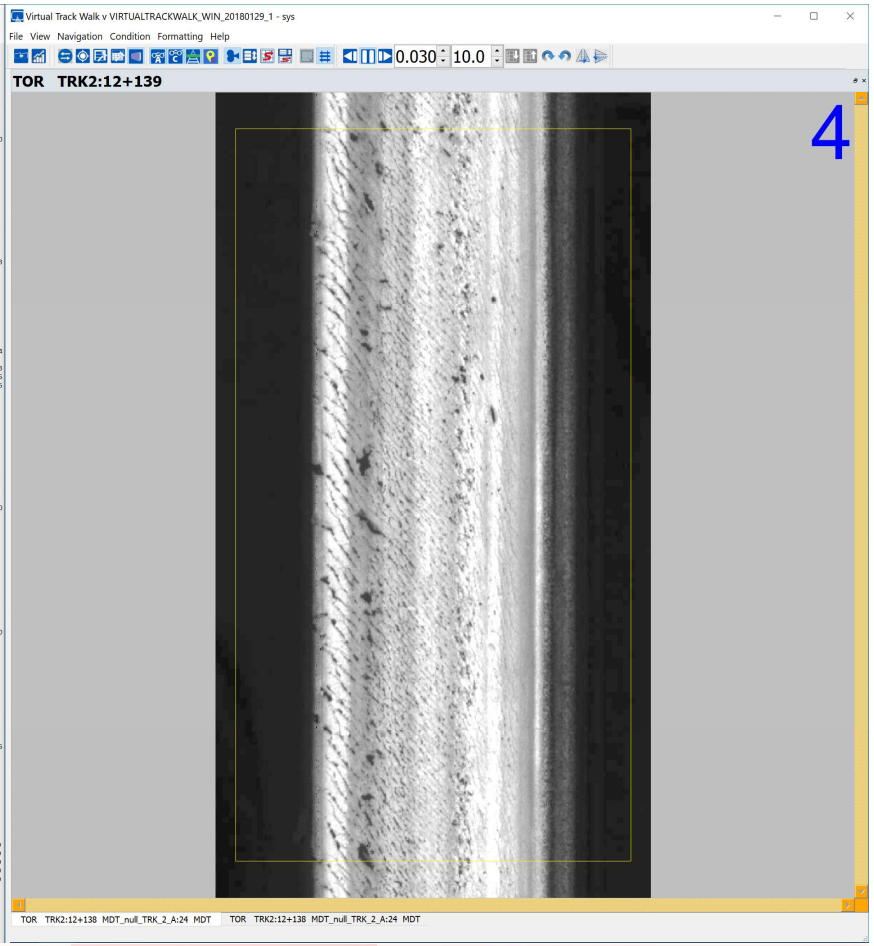
L Cant (deg)

R Cant (deg)

L FS Crack Density

R FS Crack Density





Curvature (deg)

Crosslevel (in)

Gage (in)

L Cant (deg)

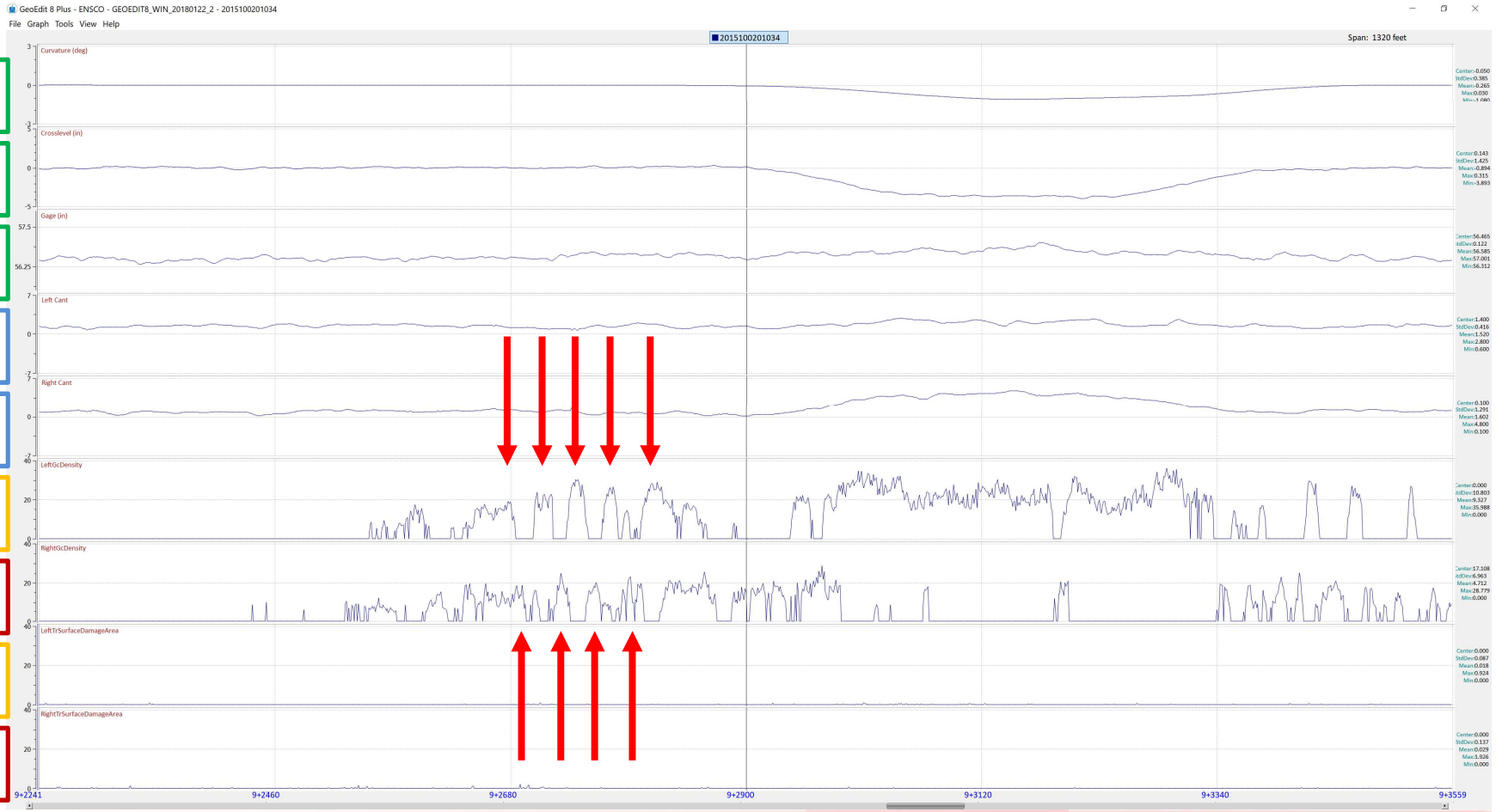
R Cant (deg)

L GF Crack Density

R GF Crack Density

L TOR Damage Area

R TOR Damage Area



Curvature (deg)

Crosslevel (in)

Gage (in)

L Rail Grinding

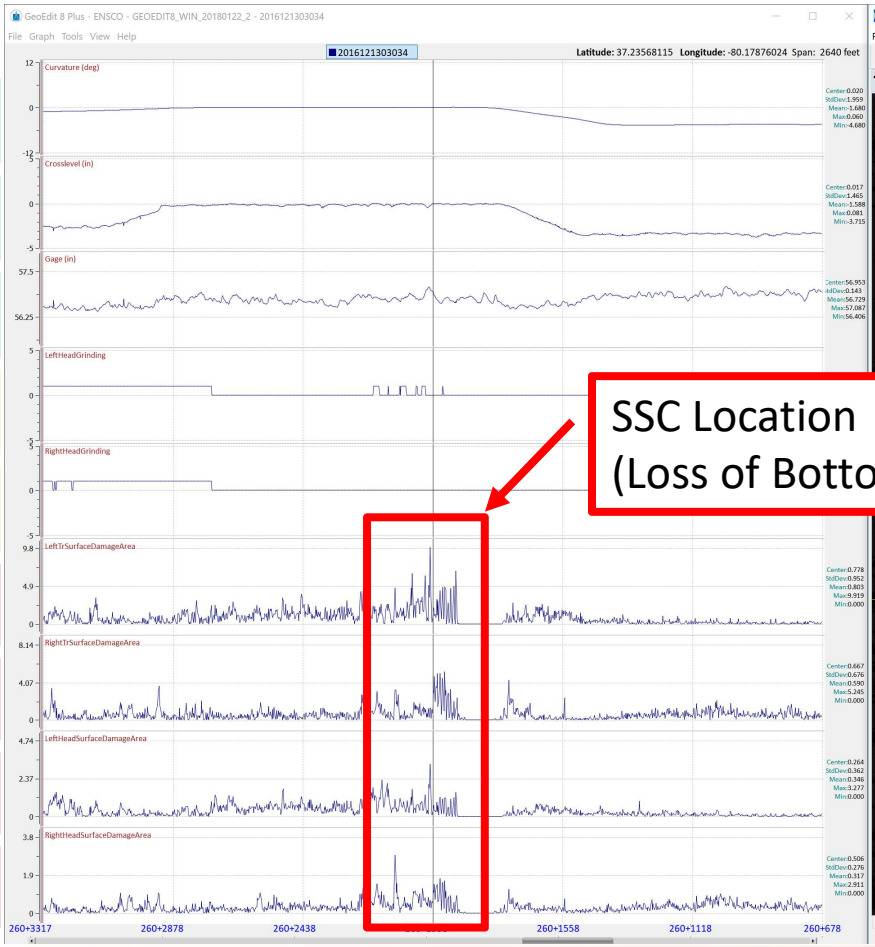
R Rail Grinding

L TOR Damage Area

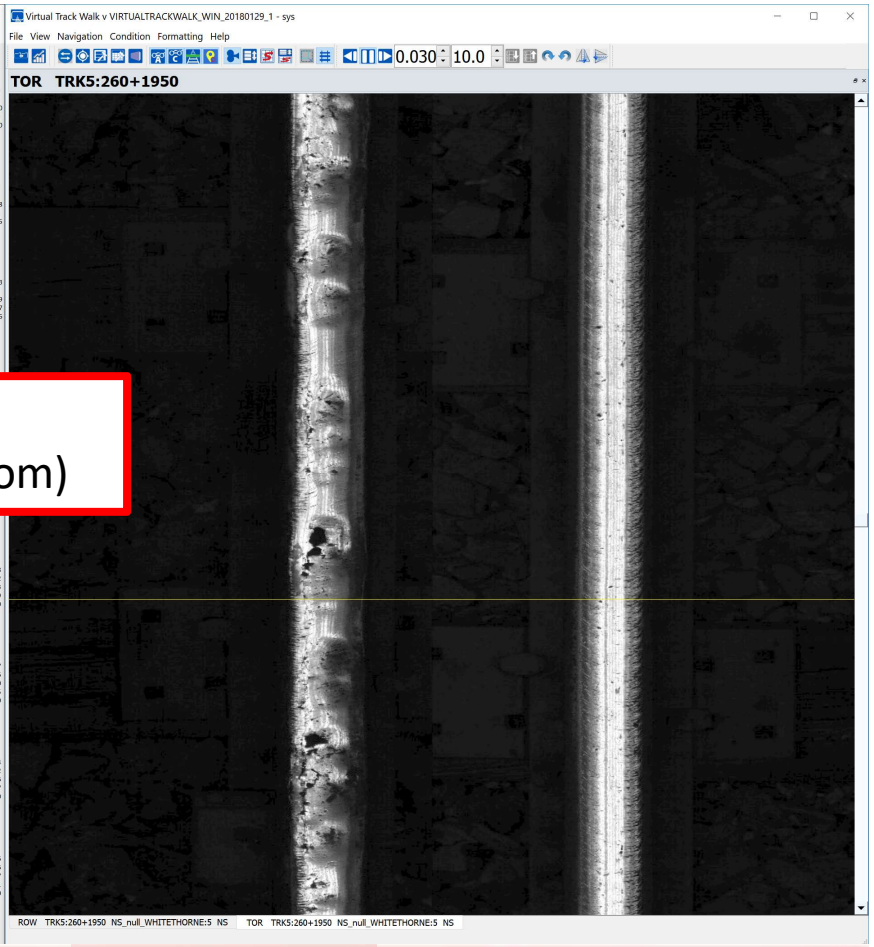
R TOR Damage Area

L Full Width Damage Area

R Full Width Damage Area



SSC Location (Loss of Bottom)



Curvature (deg)

Crosslevel (in)

L Rail Grinding

R Rail Grinding

L TOR Damage Area

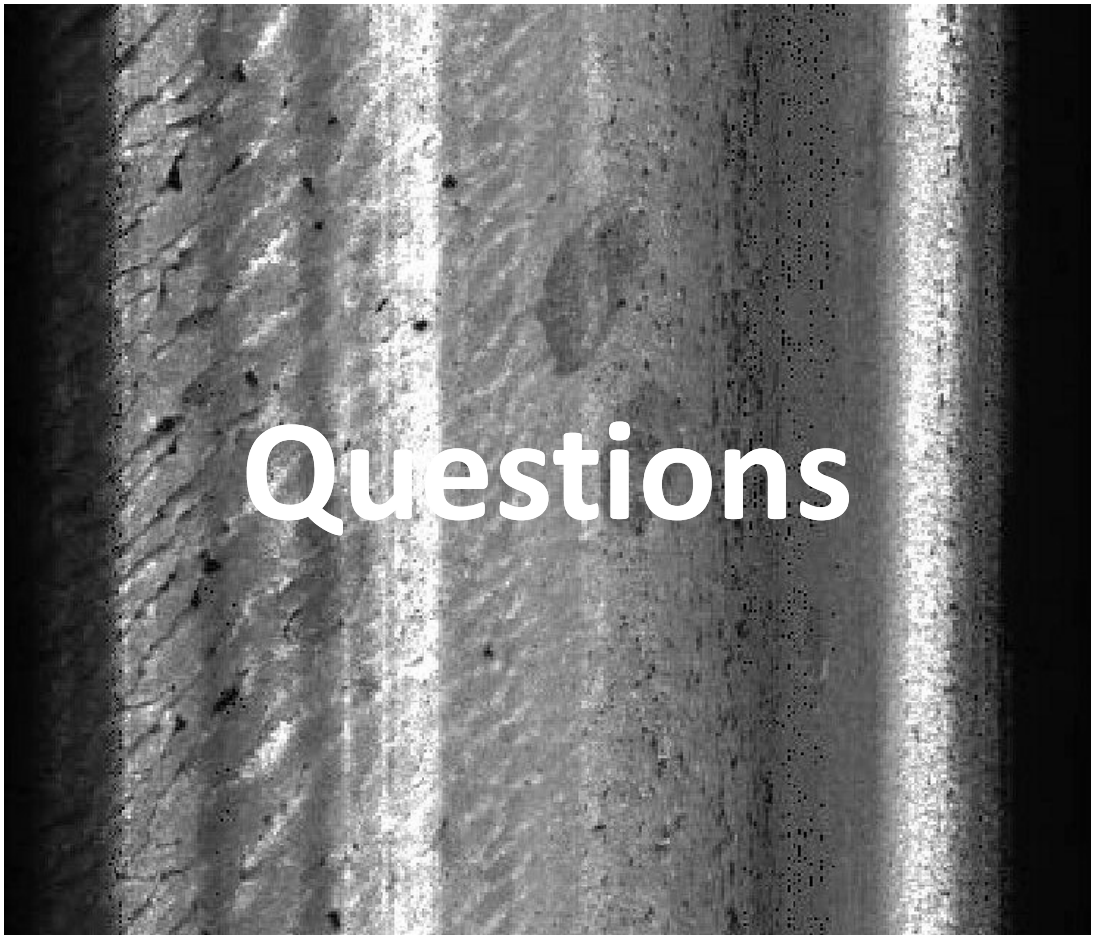
R TOR Damage Area

Surface damage near turnout.

Conclusions

- Quantifying rail surface conditions in strip chart format, opens up new doors for the rail industry for:
  - Ultrasonic Rail Flaw Testing Planning
  - Rail Condition Monitoring
  - Rail Grinding and Replacement Planning
  - RCF Research

- Next Steps
  - SSC and RCF Growth Analysis
  - RCF Root Cause Analysis
  - Pre and Post Grind Measurements


Questions