Vehicle-Track Measurement Technologies

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ENSCO Rail
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Summary

Overview of Measurement Systems

Overview of Asset Management

The Future is Here

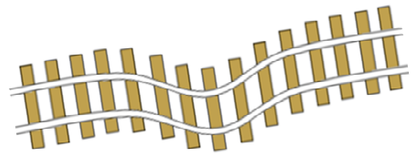
Overview of Measurement Systems

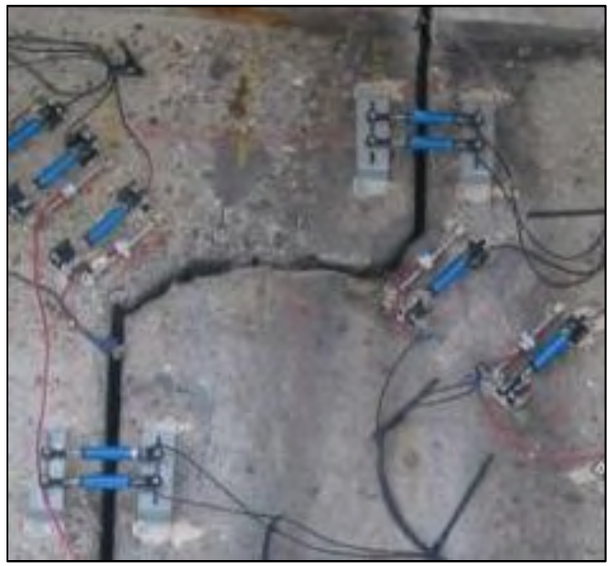
There are five basic categories of measurement system.

Categories of Measurement Systems

1) Mounted on <u>Vehicle</u> to measure the <u>Vehicle.</u>	

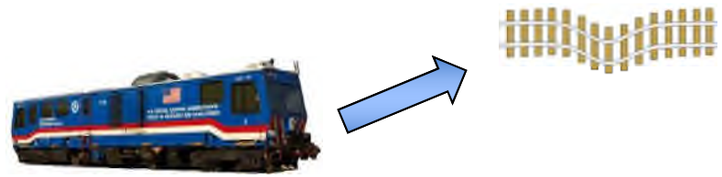
Categories of Measurement Systems

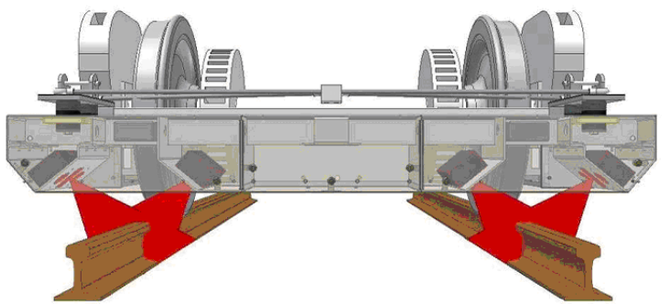
2) Mounted on <u>Track</u> to measure the <u>Track.</u>	



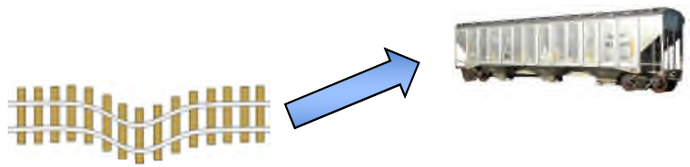
Categories of Measurement Systems

3) Mounted on Vehicle to measure the Track.
(Manned, Unmanned, and Autonomous)

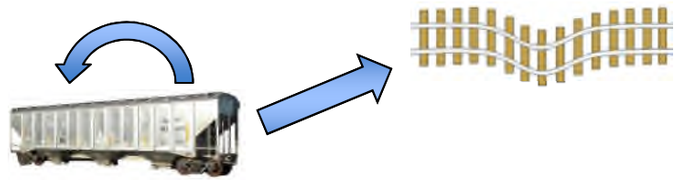


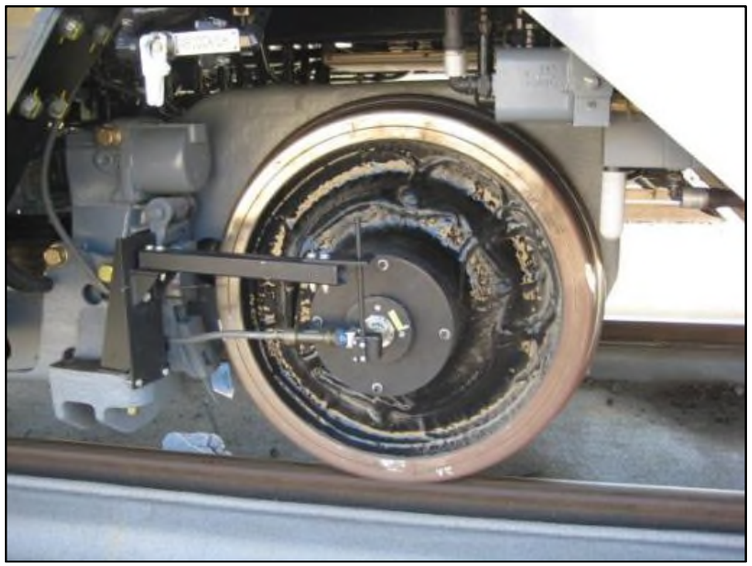


Categories of Measurement Systems

4) Mounted on <u>Track</u> to measure the <u>Vehicle.</u>	

Categories of Measurement Systems

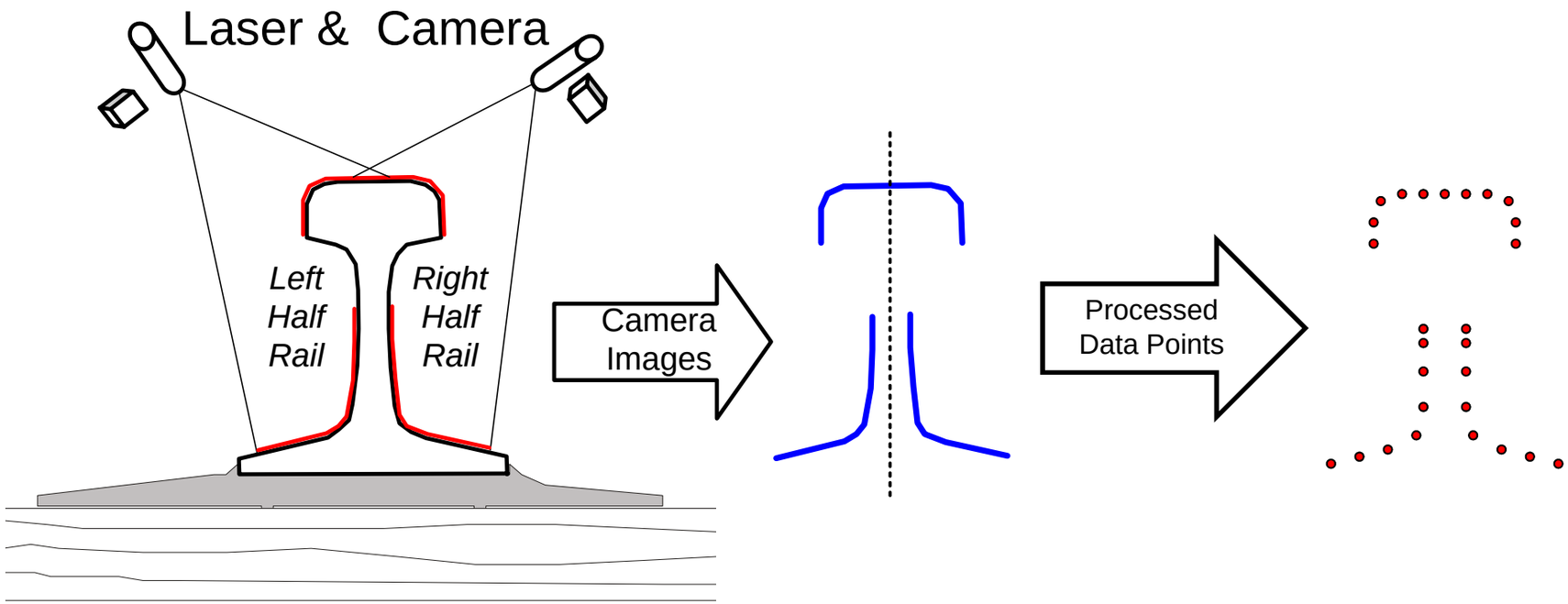
5) Mounted on <u>Vehicle</u> to measure the <u>Vehicle & Track.</u>	



Track Measurement		Vehicle Measurement
Rail Profile Measurement System	⟷	Wheel Profile Detector
Track Geometry Measurement	⟷	Truck Condition Monitor (TBOGI)
V/TI Monitor Axle Impact	⟷	Wheel Impact Load Detector
Ultrasonic Rail Flaw Detector	⟷	Cracked Wheel Detector
Machine Vision	⟷	Machine Vision

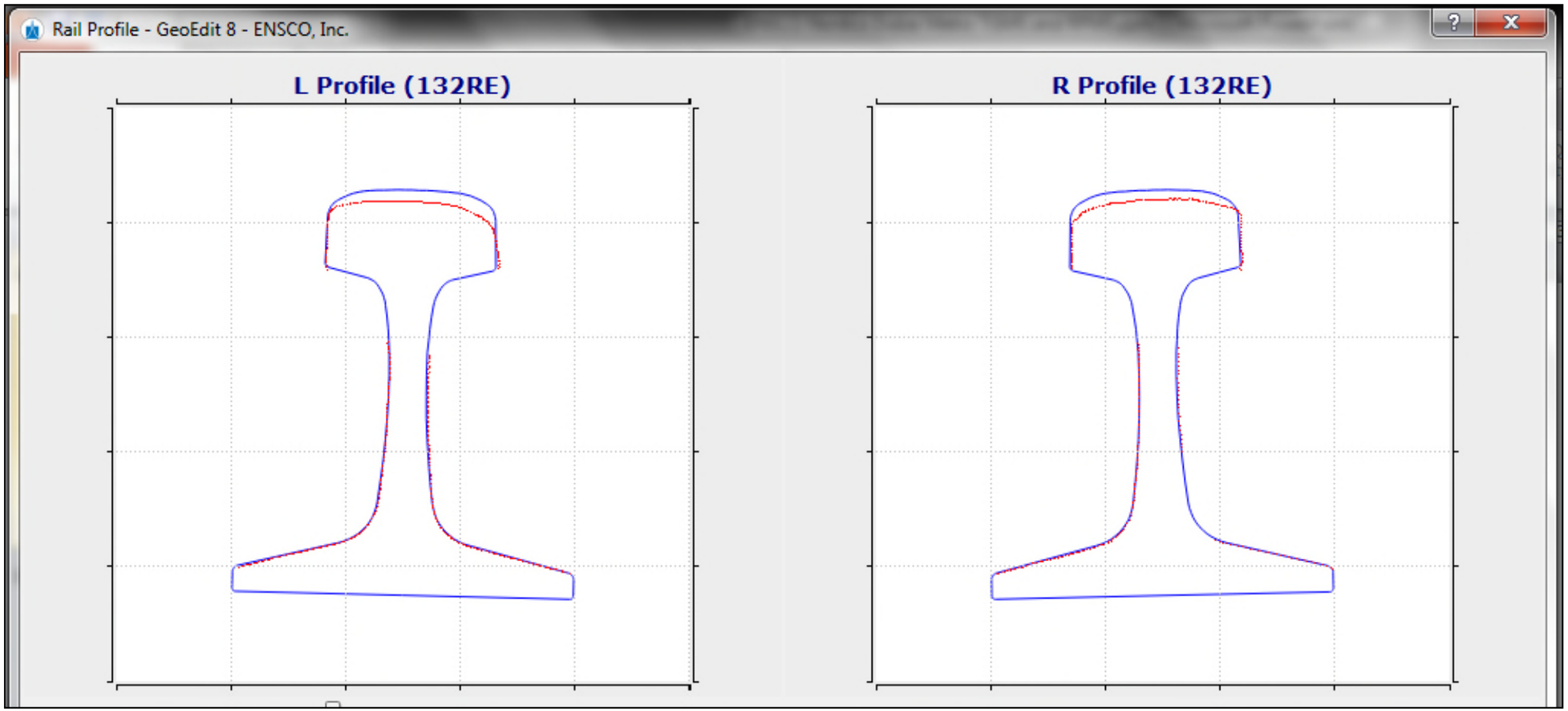
Profile Measurement

Laser Triangulation Measurement

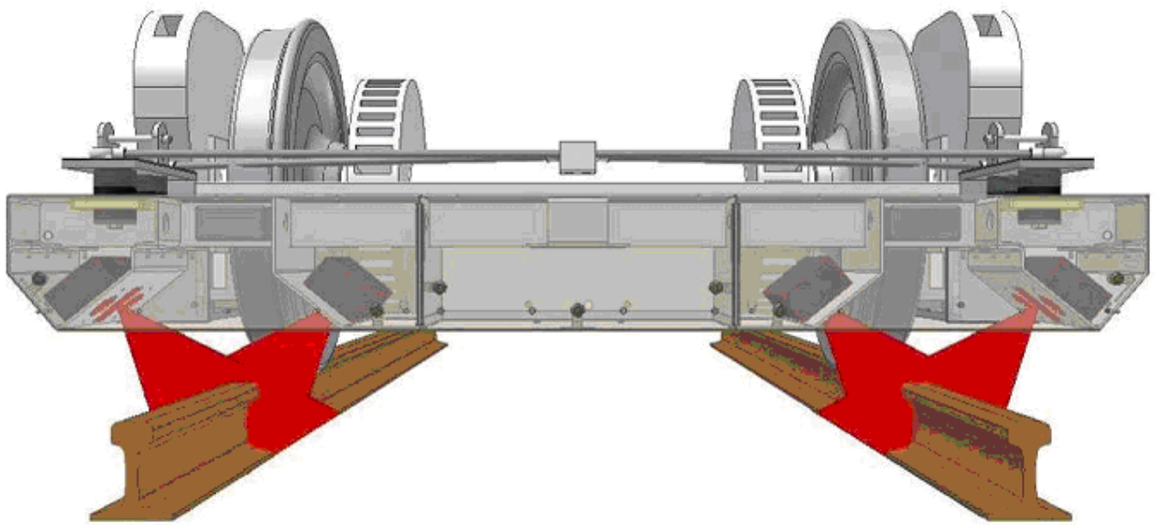


Ref 1

Laser Triangulation Measurement



Rail Profile Measurement System



Vehicle Platforms:

Railbound Manned

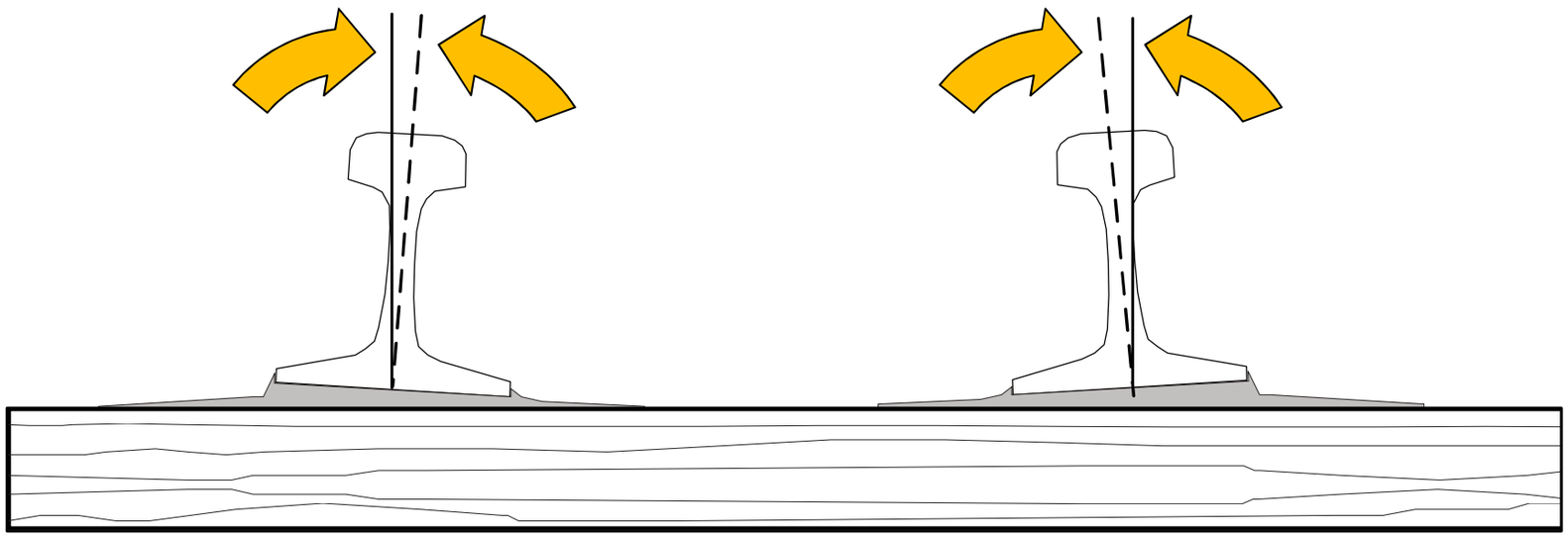
Hi-Rail Manned

Autonomous

Absolute Measurements:

(Doesn't Require Template)

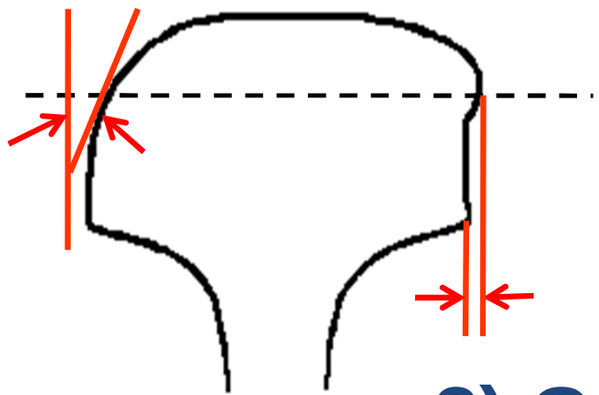
1) Cant (Deg)



Absolute Measurements:

(Doesn't Require Template)

2) Gage Face Angle (Deg)

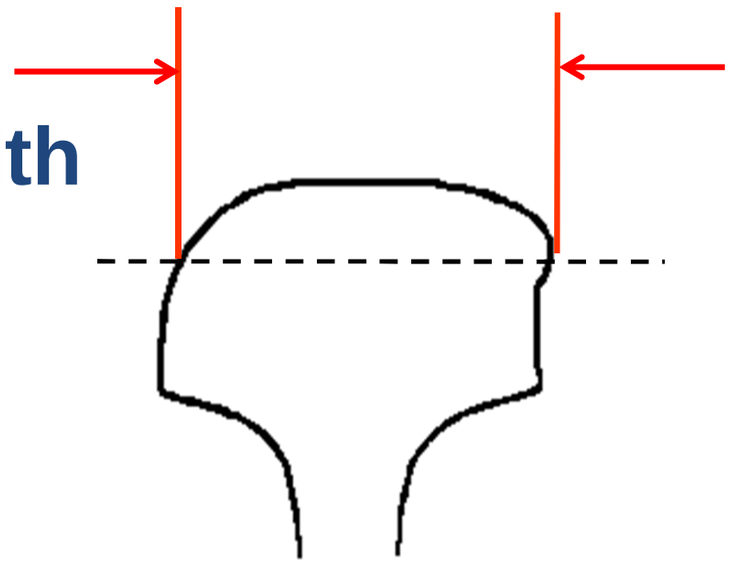


3) Gage/Field Side Lip (In, mm)

Absolute Measurements:

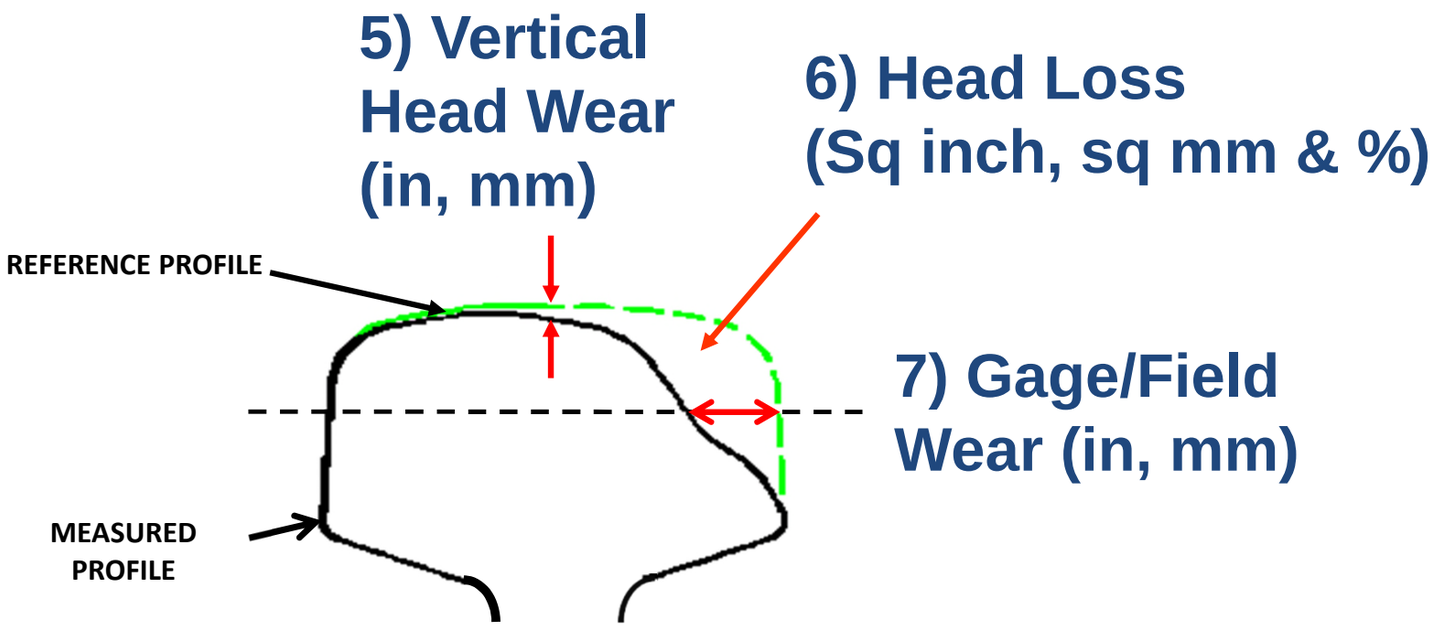
(Doesn't Require Template)

4) Head Width (in, mm)



Relative Measurements:

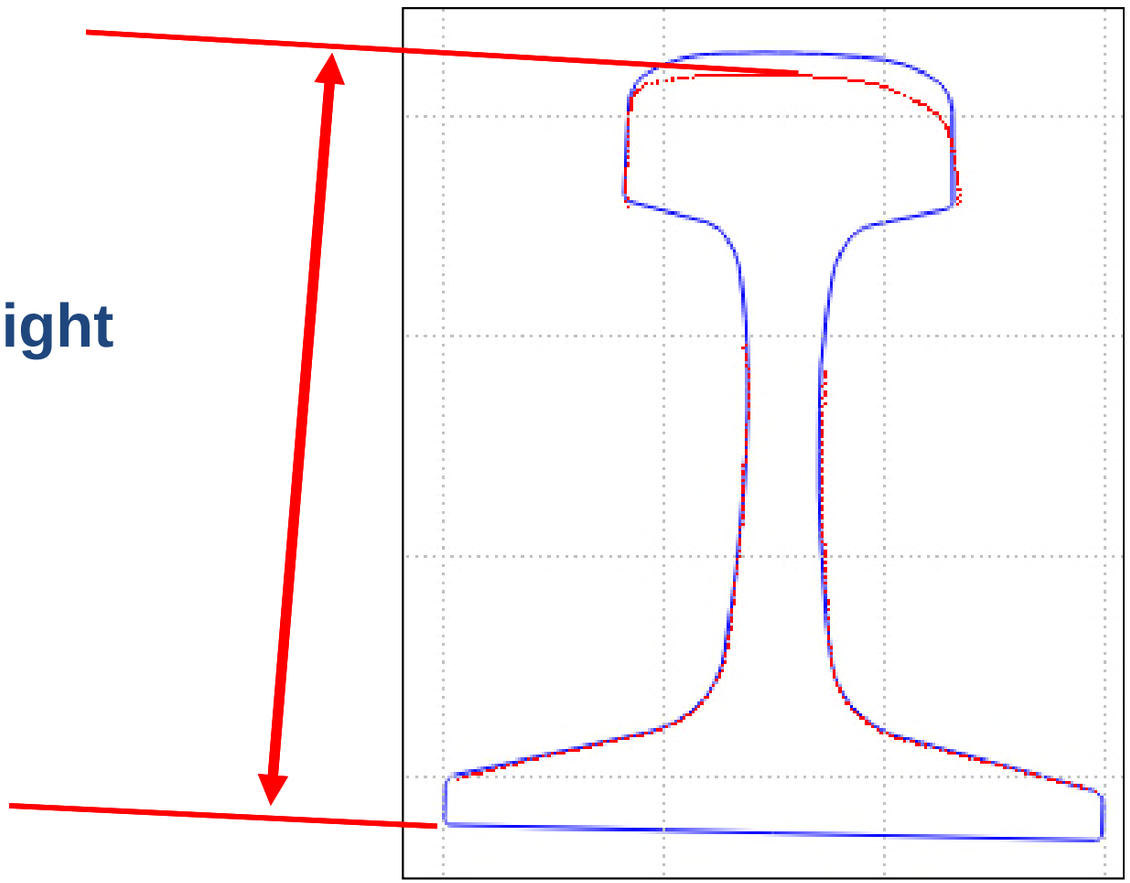
(Does Require Template)

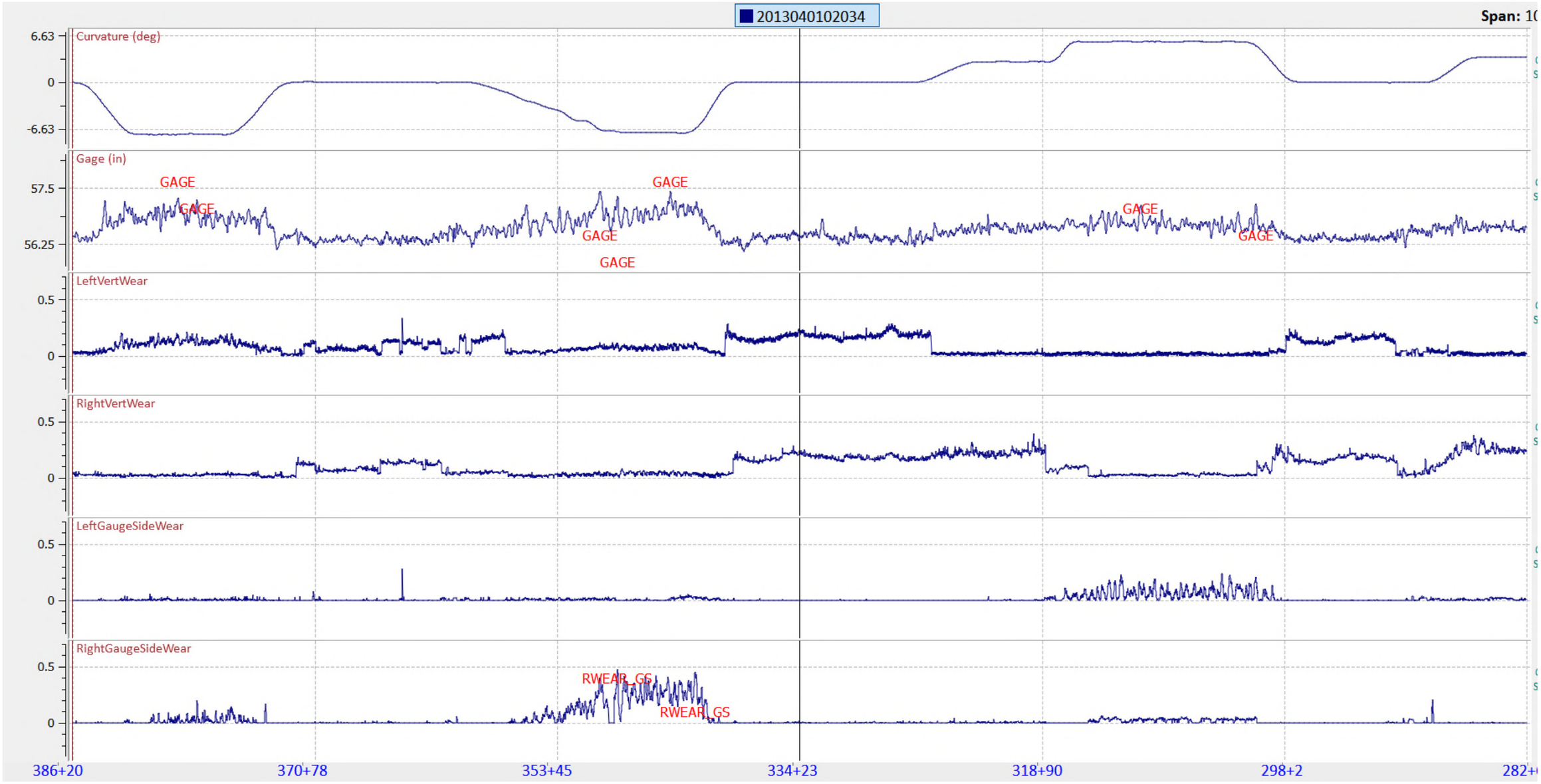


Relative Measurements:

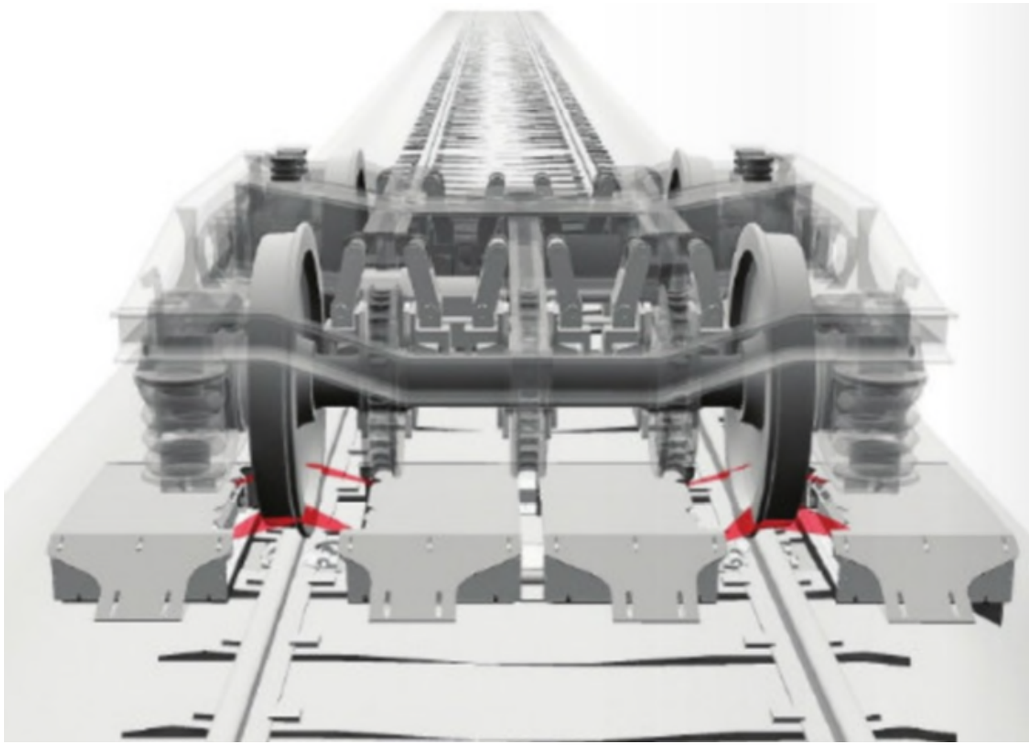
(Does Require Template)

8) Total Height (in, mm)

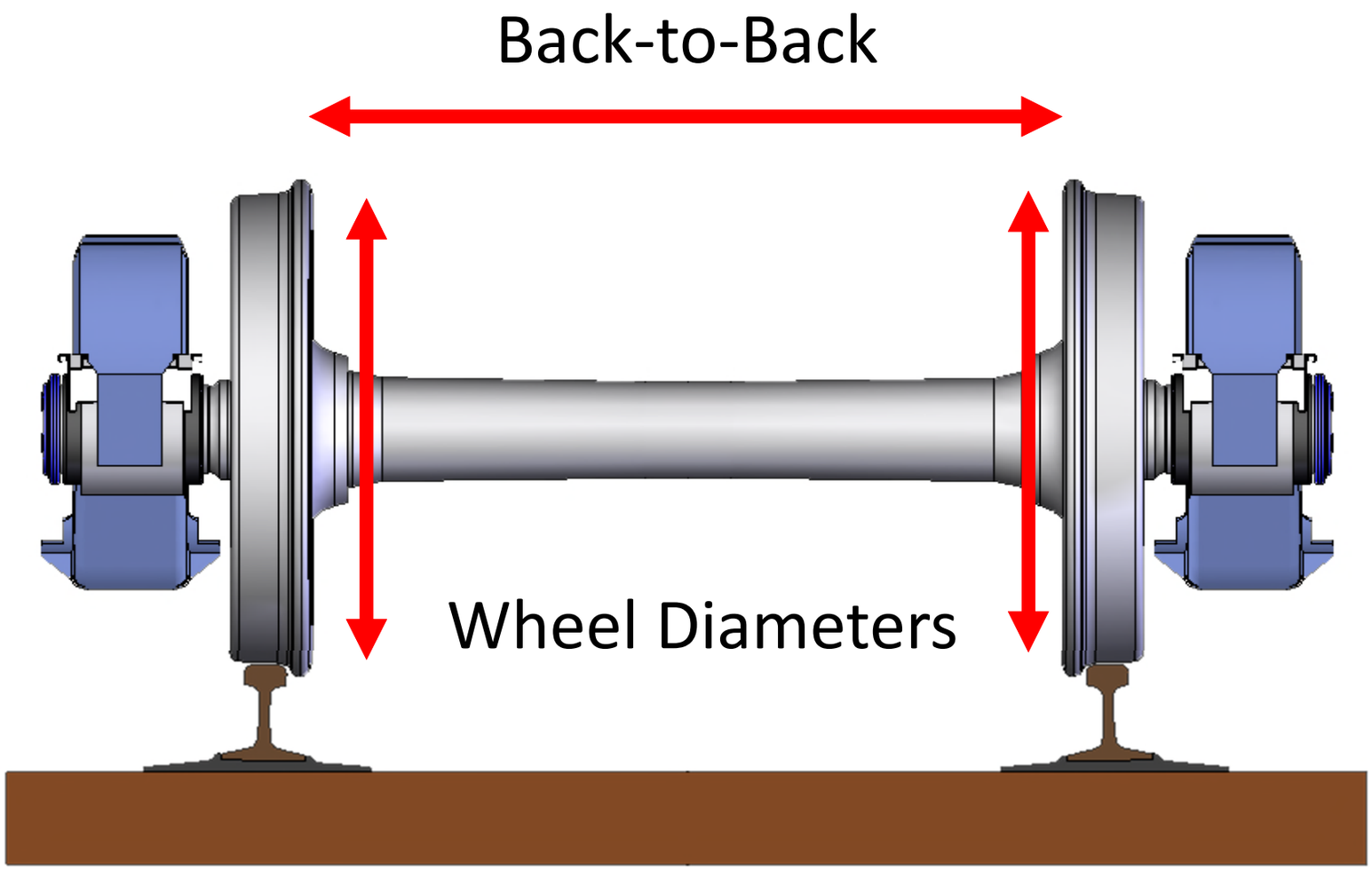


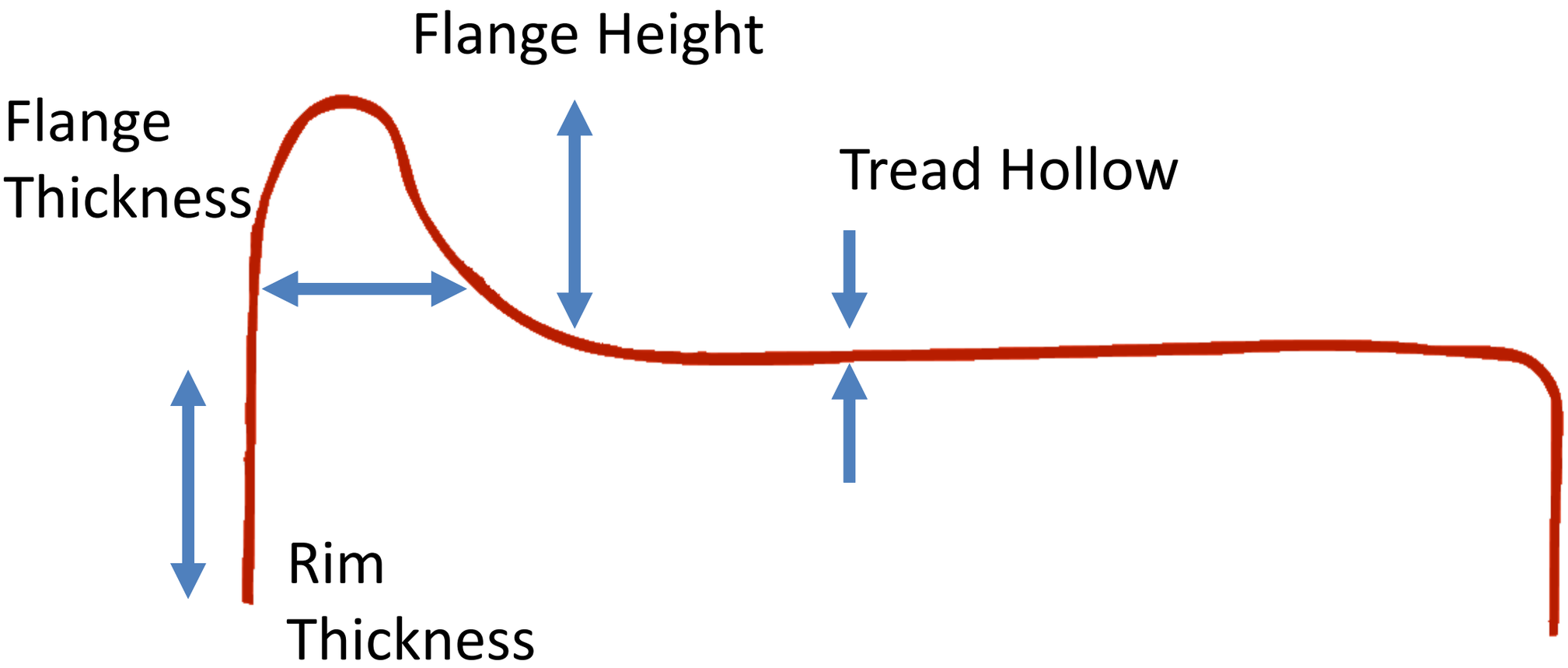

2013040102034
Span: 10
Curvature (deg)
6.63
0
-6.63
Gage (in)
57.5
56.25
GAGE
GAGE
GAGE
GAGE
GAGE
GAGE
GAGE
LeftVertWear
0.5
0
RightVertWear
0.5
0
LeftGaugeSideWear
0.5
0
RightGaugeSideWear
0.5
0
RWEAR_GS
RWEAR_GS
386+20
370+78
353+45
334+23
318+90
298+2
282+

Wheel Profile Detector



Images from Beena Vision
http://www.beenavision.com/BV_Brochure_2016/mobile/index.html#p=16

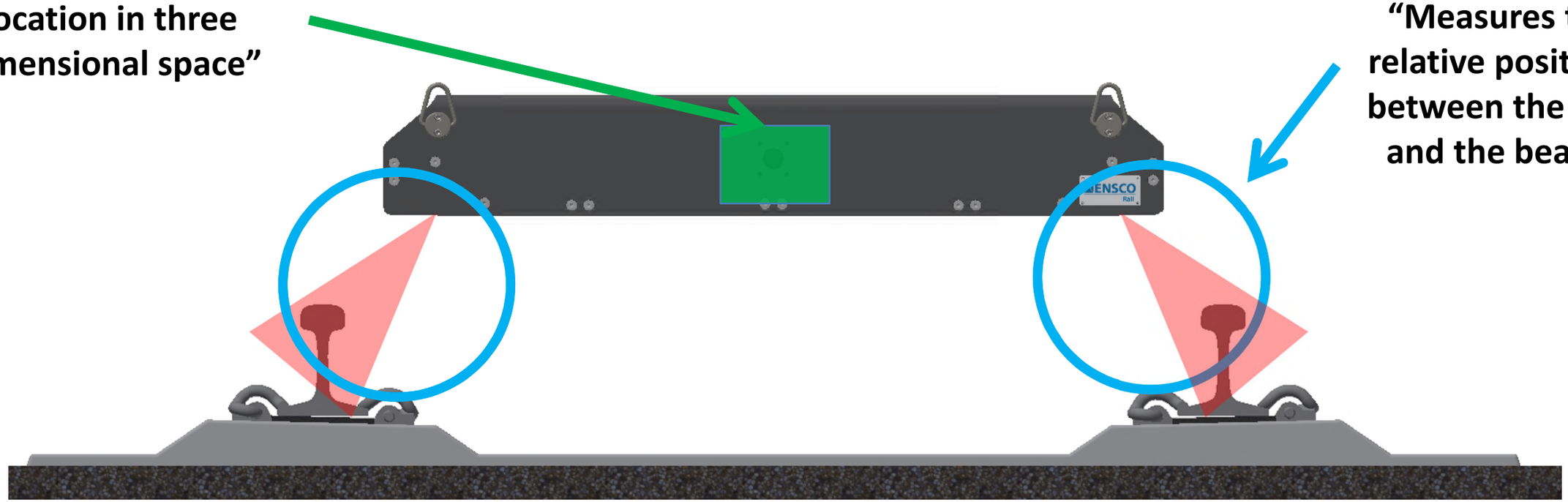

Back-to-Back
Wheel Diameters


Flange Height
Flange Thickness
Tread Hollow
Rim Thickness

Geometry Measurement

Track Geometry Measurement System

Inertial Package "Measures the beam location in three dimensional space"



Laser/Cameras "Measures the relative positions between the rails and the beam"

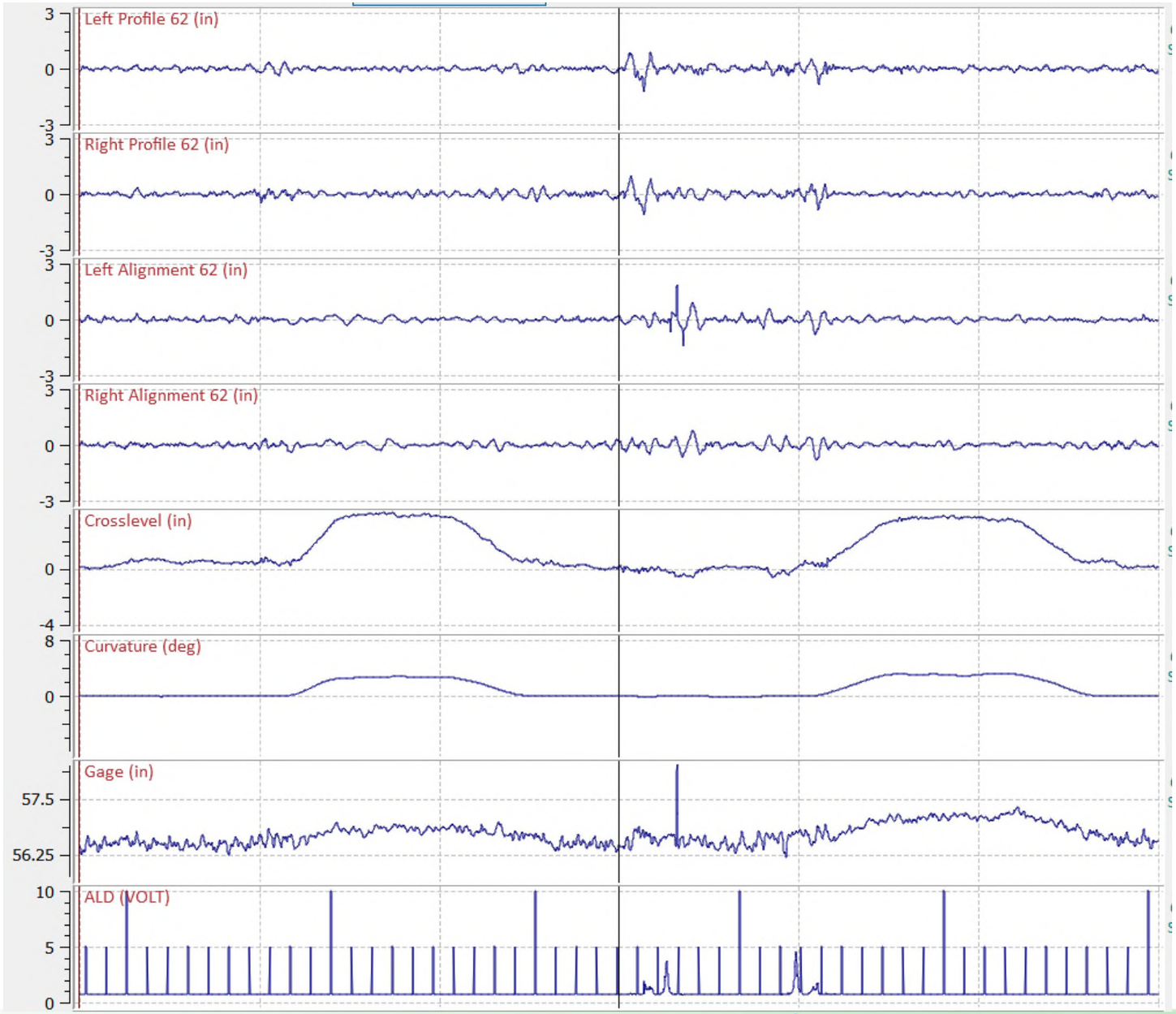
Vehicle Platforms:

Railbound Manned

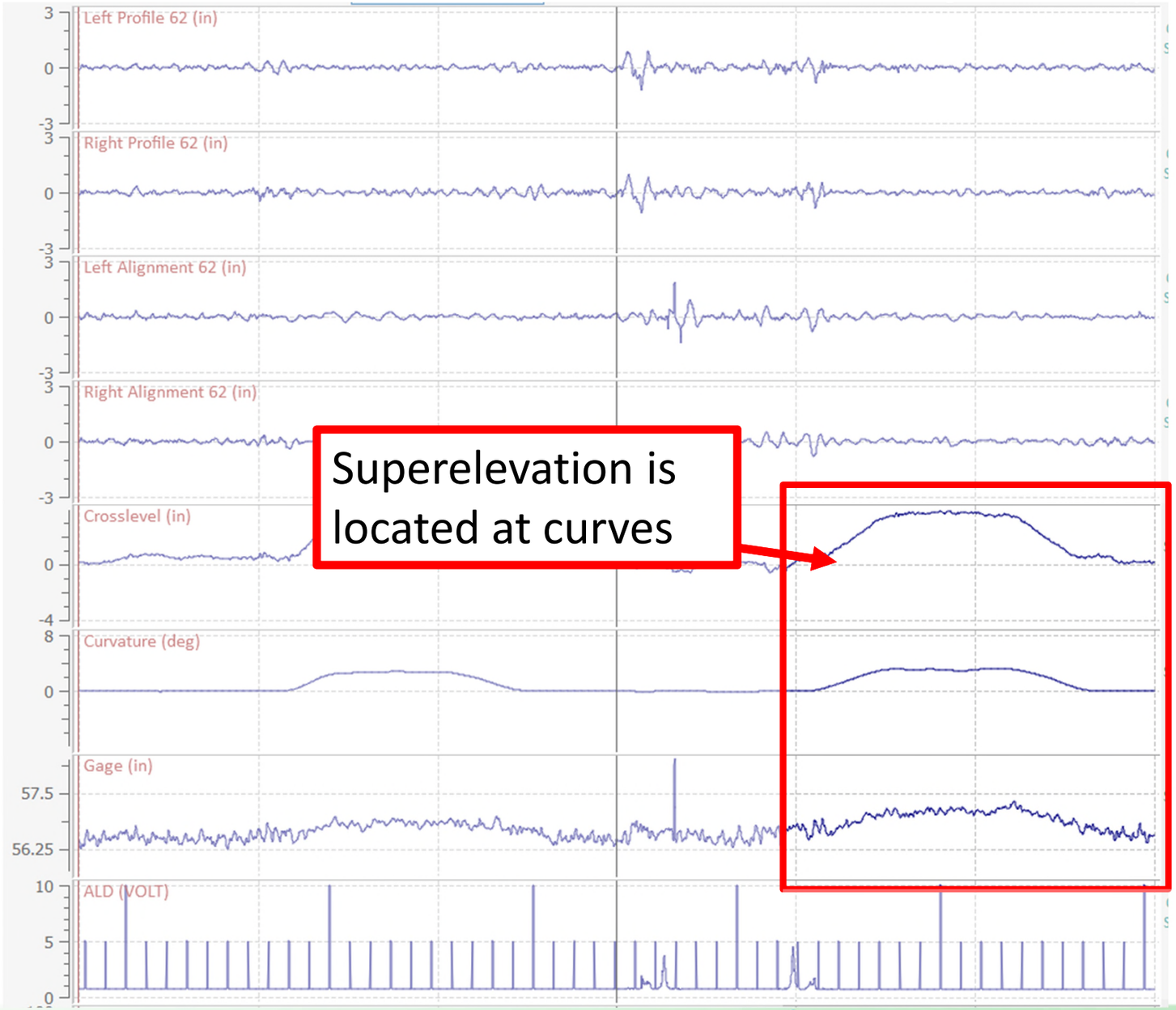
Hi-Rail Manned

Autonomous

Example Track Geometry Strip Chart



Example Track Geometry Strip Chart



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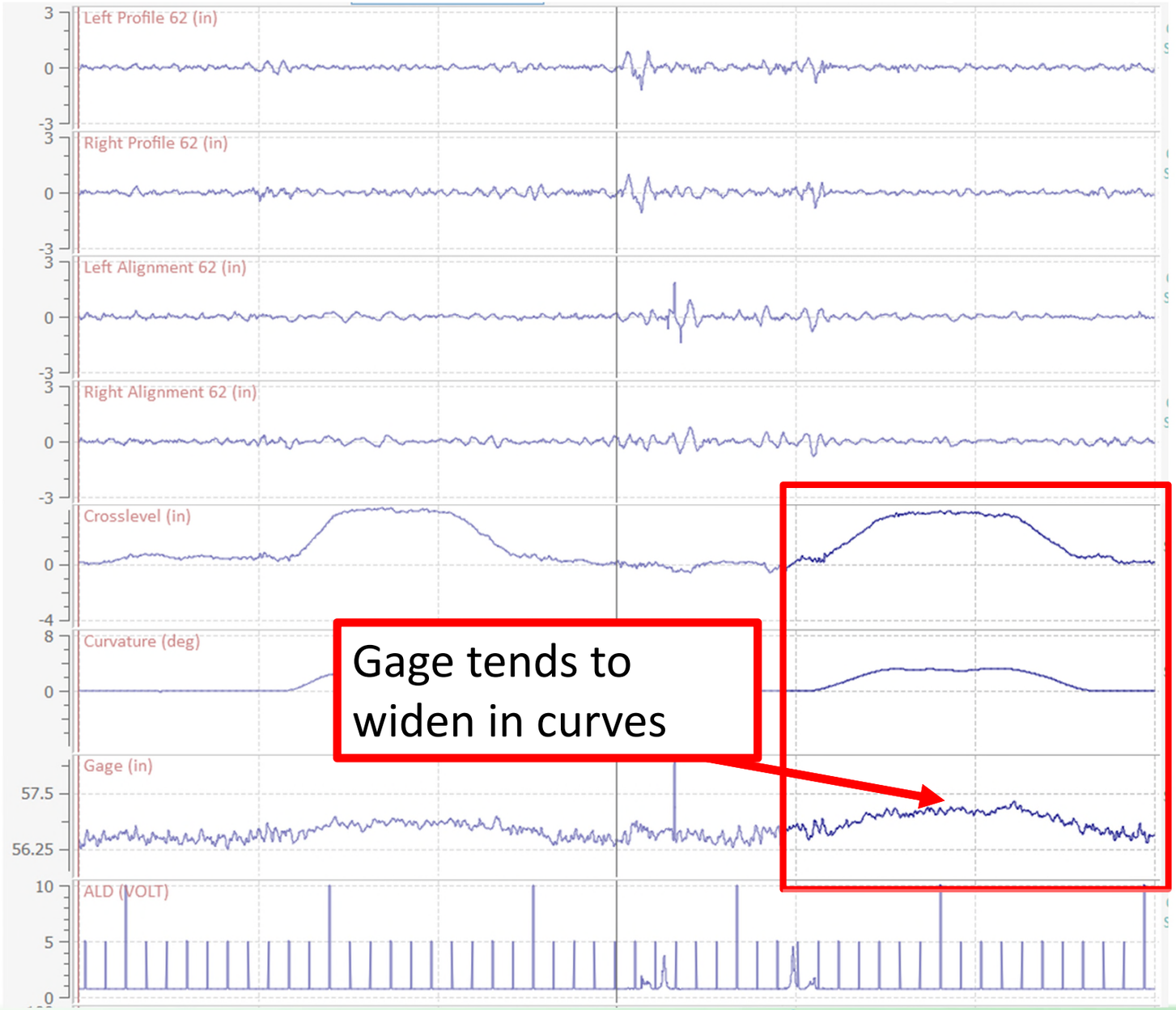

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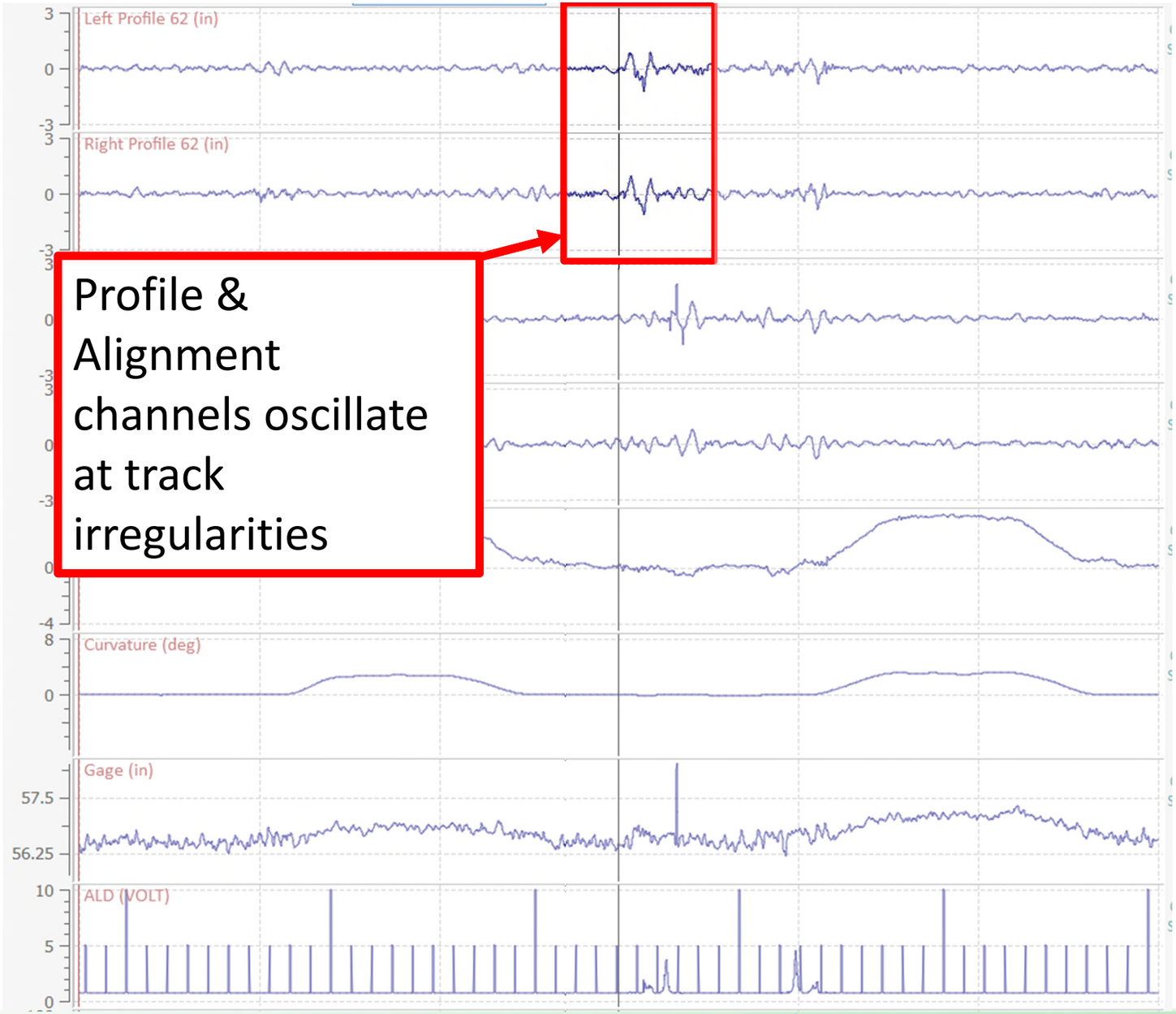

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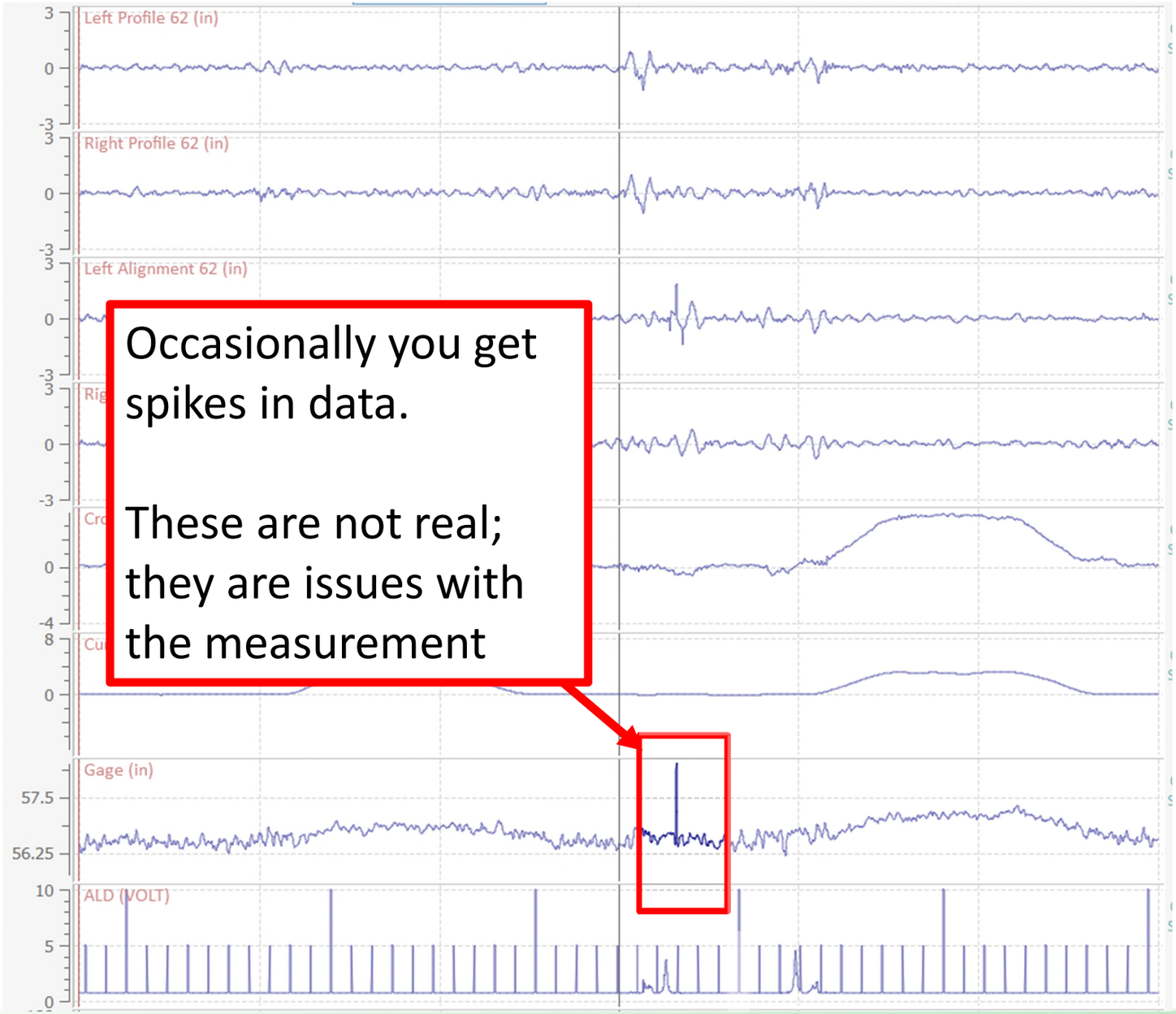

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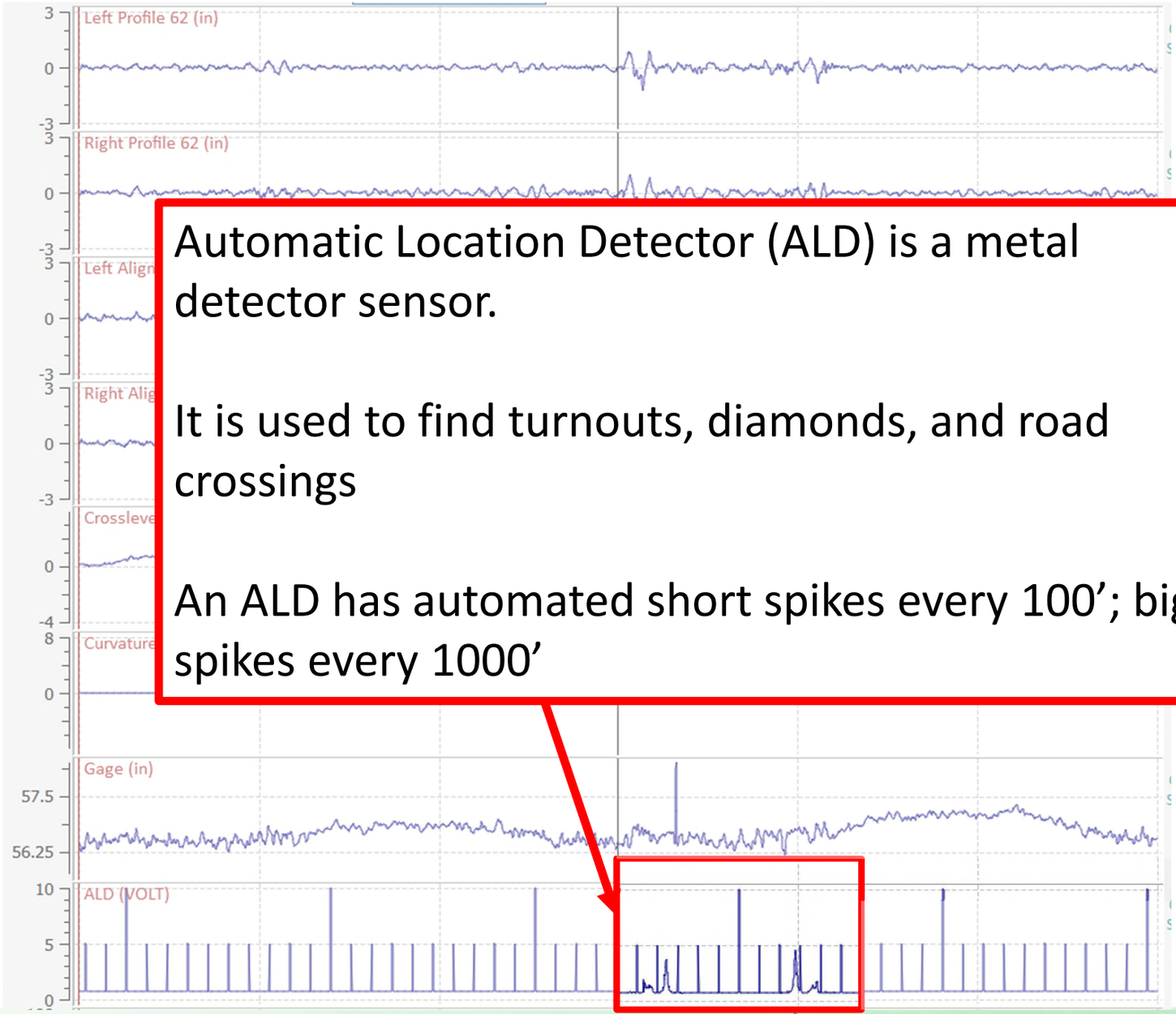
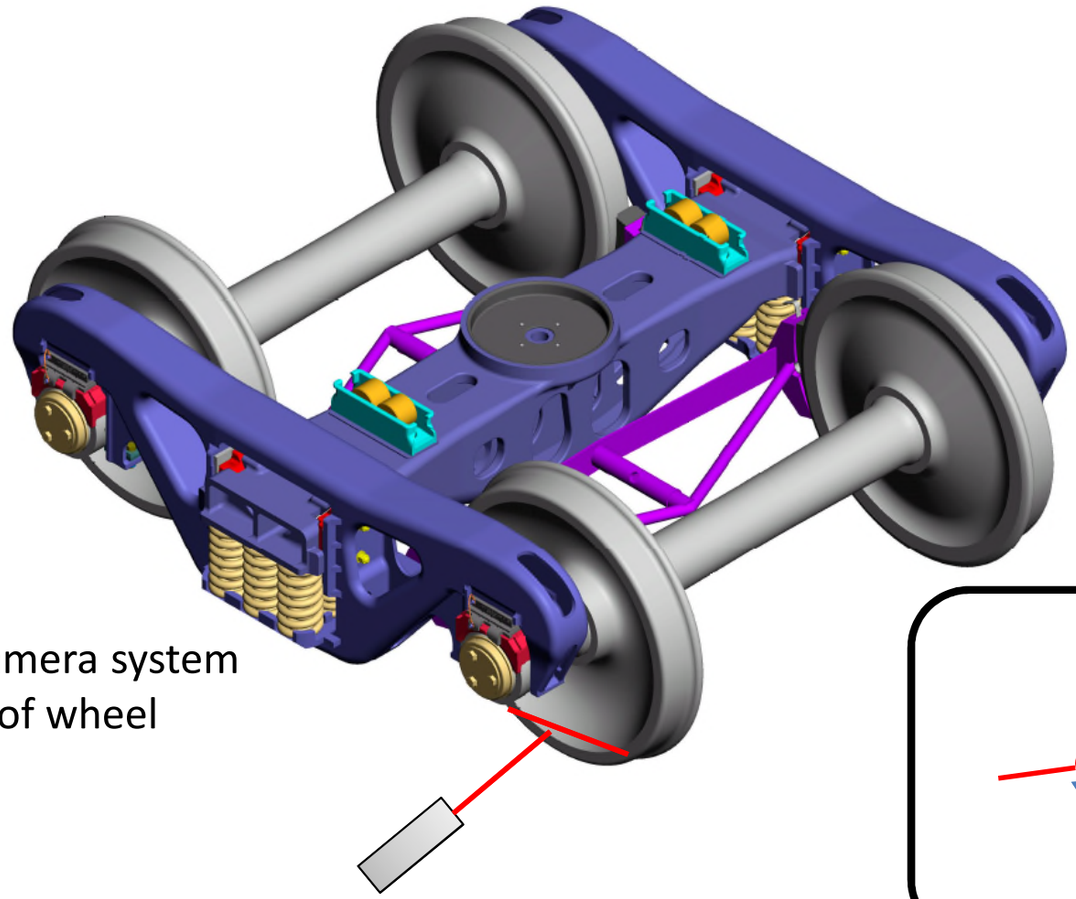


Automatic Location Detector (ALD) is a metal detector sensor.

It is used to find turnouts, diamonds, and road crossings

An ALD has automated short spikes every 100’; big spikes every 1000’

Truck Condition Monitor (T-BOGI)



Wayside Laser/Camera system measures profile of wheel plate.

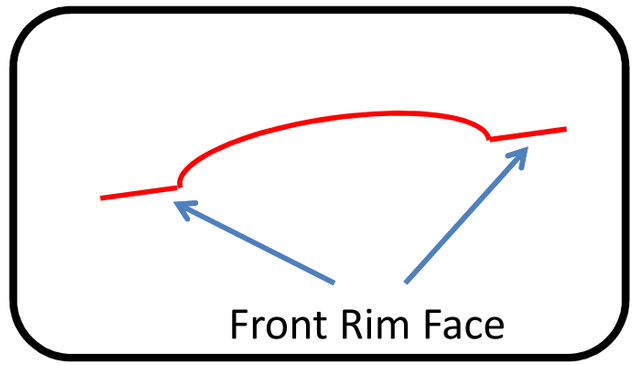
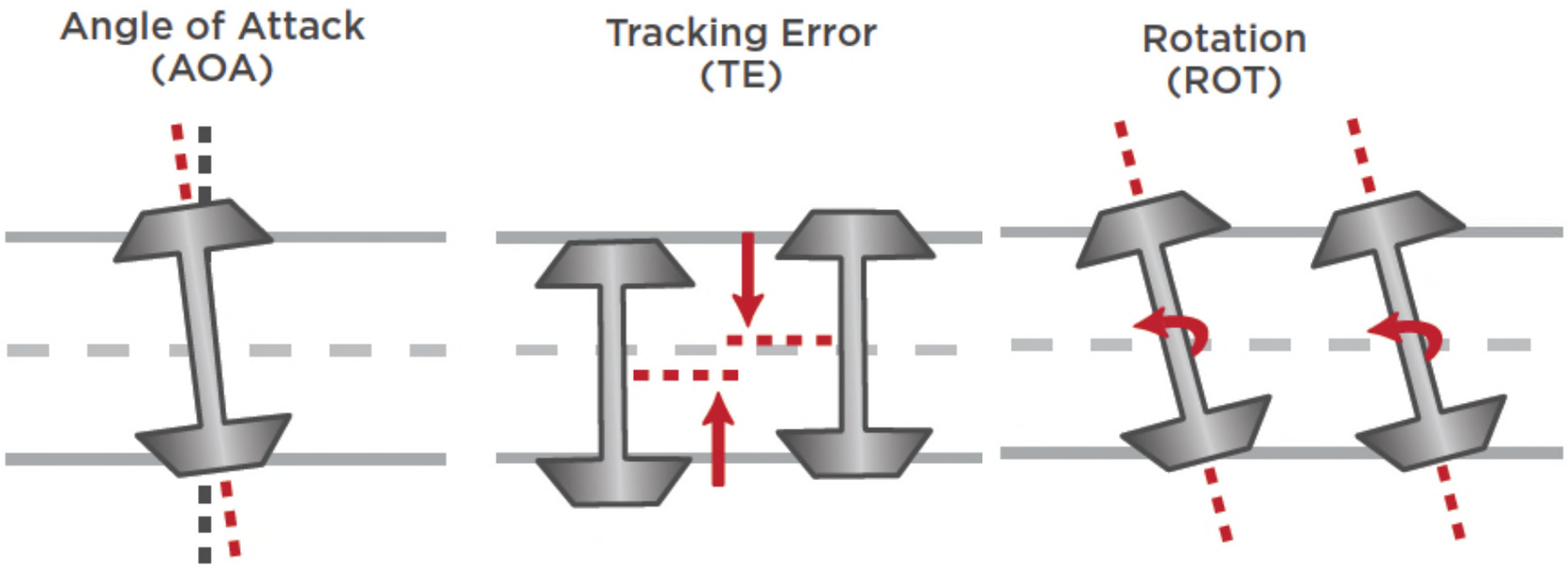


Image from Standard Car and Truck Maintenance Manual
http://www.sctco.com/pdf/Section1.pdf

How does a truck condition monitor work?



Images from Wayside Inspection Systems
http://wid.ca/sites/default/files/brochures/TBOGI/WID_TBOGI_Brochure_US.pdf

Impact Measurement

Wheel Impact Load Detector (WILD)

Image from L.B. Foster
https://www.youtube.com/watch?v=7CJycCggHgw

Image from Frauscher
https://www.youtube.com/watch?v=gTfU4tGZzgo

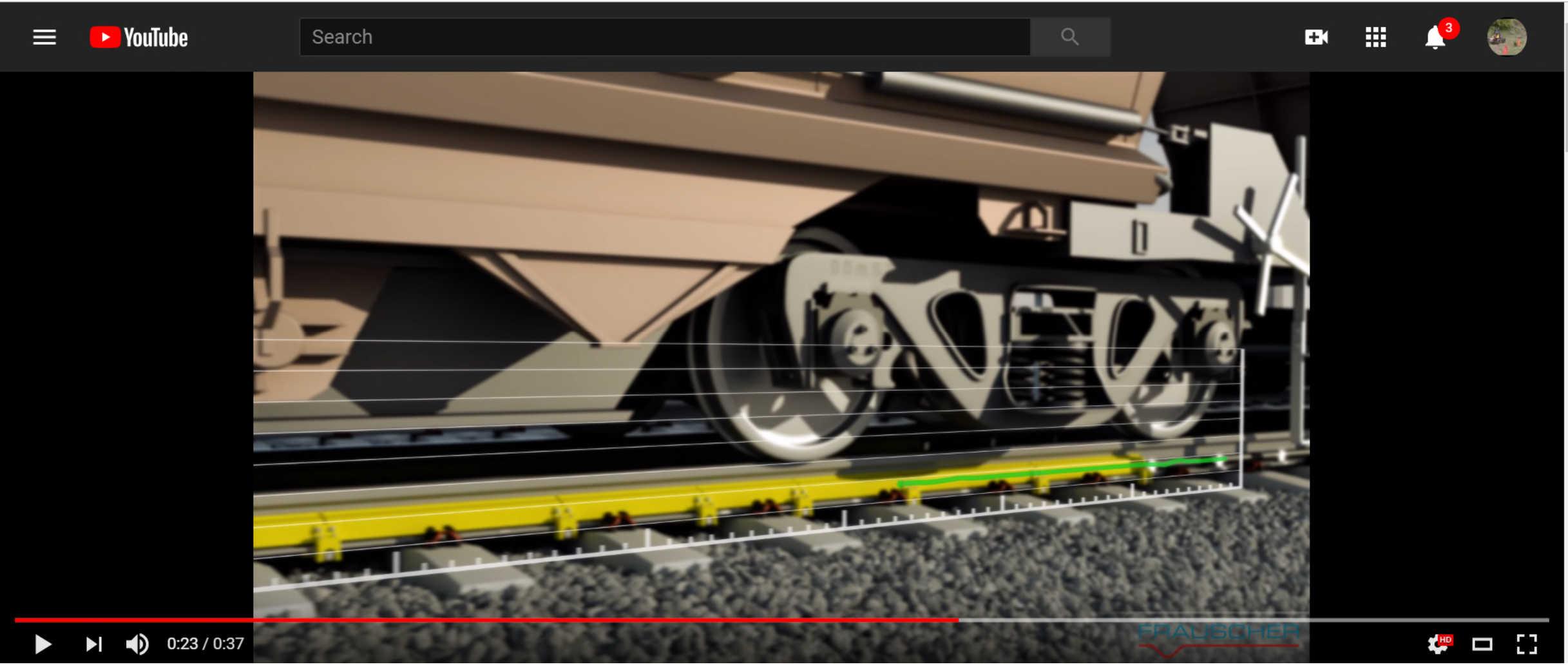


Image from Frauscher
https://www.youtube.com/watch?v=gTfU4tGZzgo

Image from Frauscher
https://www.youtube.com/watch?v=gTfU4tGZzgo

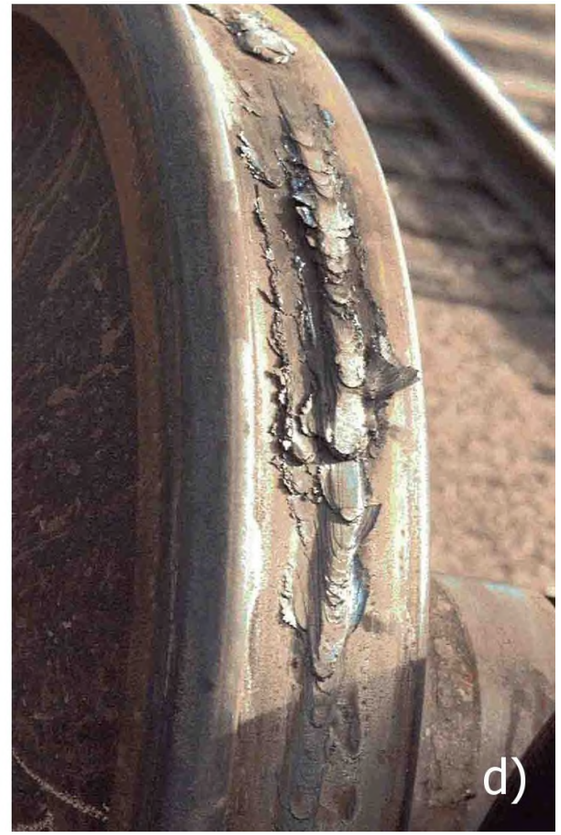
Image from Frauscher
https://www.youtube.com/watch?v=gTfU4tGZzgo

Example WILD Defects

Slid Flat

Shelling & Spalling

Shattered Rim



Built Up Tread

Measurements

- Nominal Load
- Peak Load
- Dynamic Load (=Peak-Nominal)
- Ratio (=Peak/Nominal)

Things to Keep in Mind

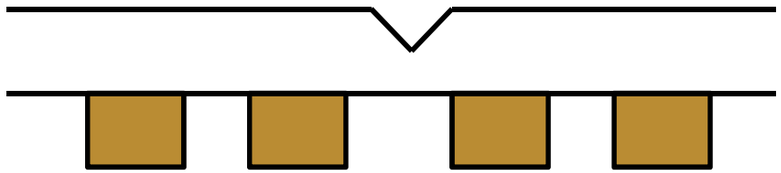
- Loaded/Empty
- Speed
- Track Stiffness

V/TI Monitor – Impact Measurement

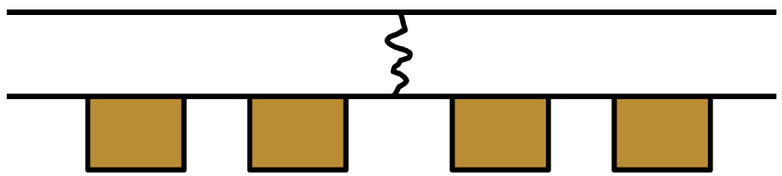
Example V/TI Monitor Axle Sensor

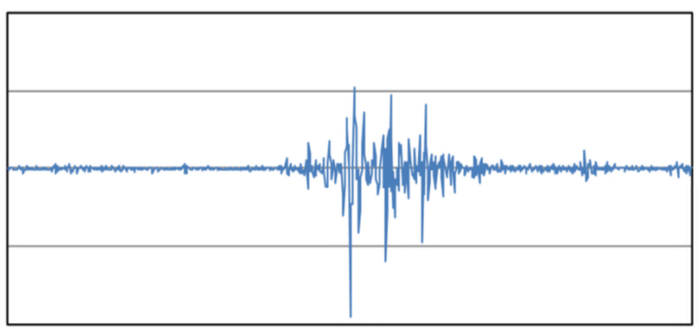
Vehicle Platforms:
Revenue Vehicles

Dent



Break





- Vertical acceleration measured at axle box
- Wheel/Rail Impact acceleration measured
- Peak acceleration is used to calculate peak load.

Example V/TI Monitor Defects

Battered Joint

Cracked/Broken Joint Bar

Cracked/Broken Frog

Broken Rail

Measurements

- Peak Load

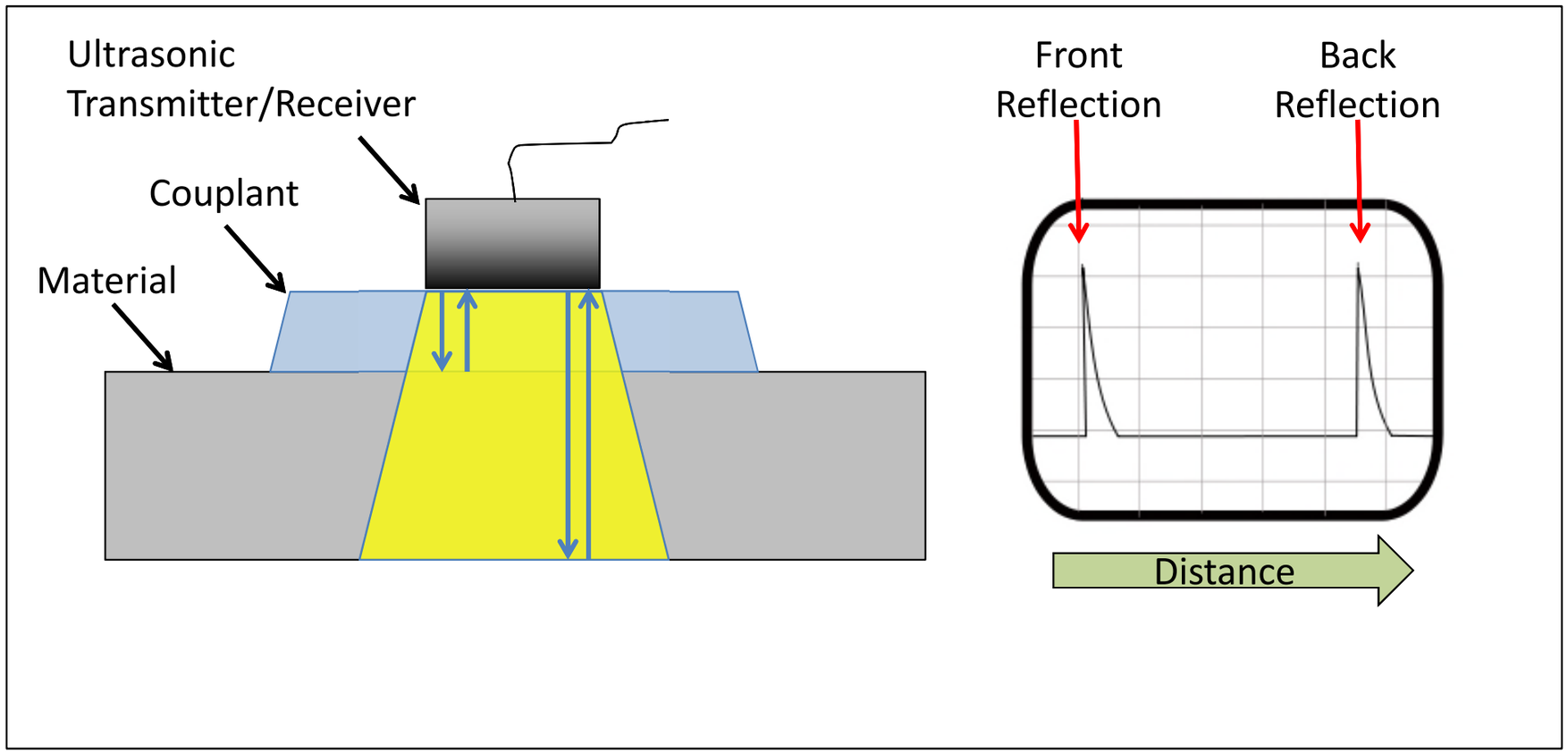
Things to Keep in Mind

- Loaded/Empty
- Speed
- Track Stiffness

Ultrasonic Measurement

Ultrasonic Sensors

- Can measure depth, size, and orientation of internal flaws in a material



Ultrasonic Sensors

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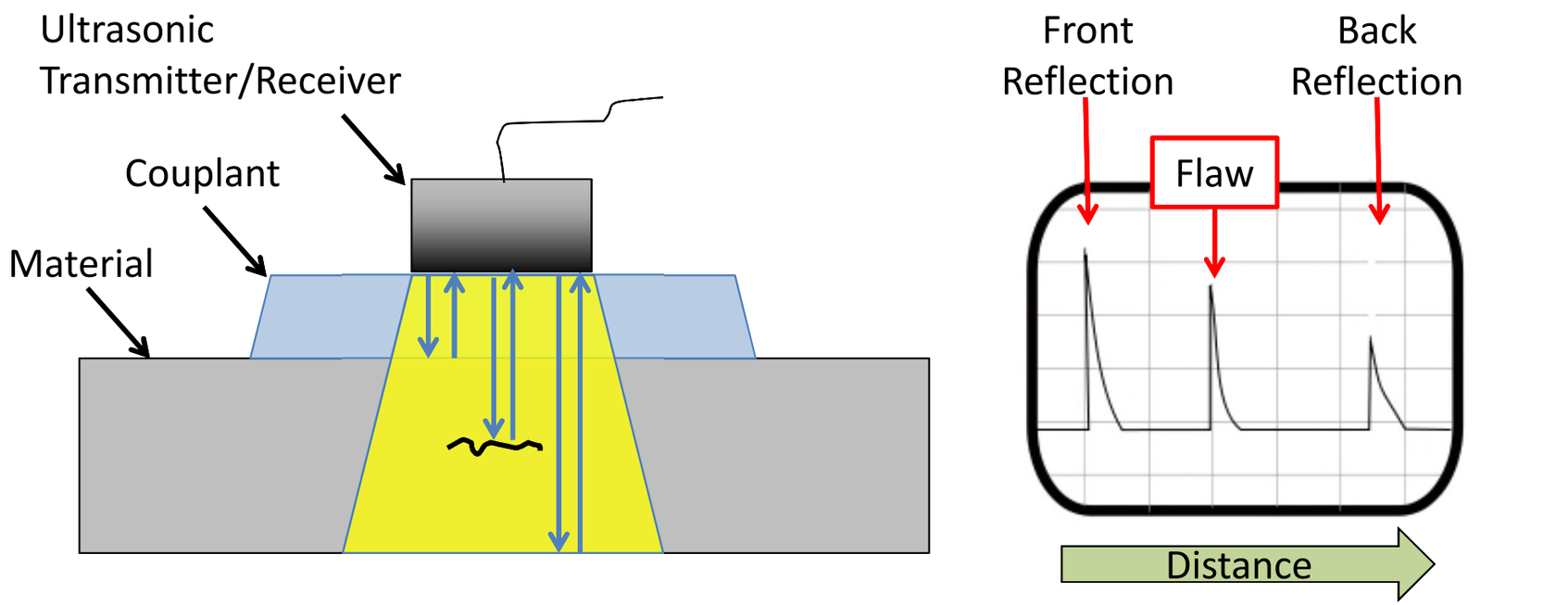


- Uses ultrasonic waves to reflect from surfaces and measure the “time of flight” to determine distance.

Ultrasonic Rail Flaw Detectors

Exampled Wheel Probe System
(Most Commonly Used in North America)

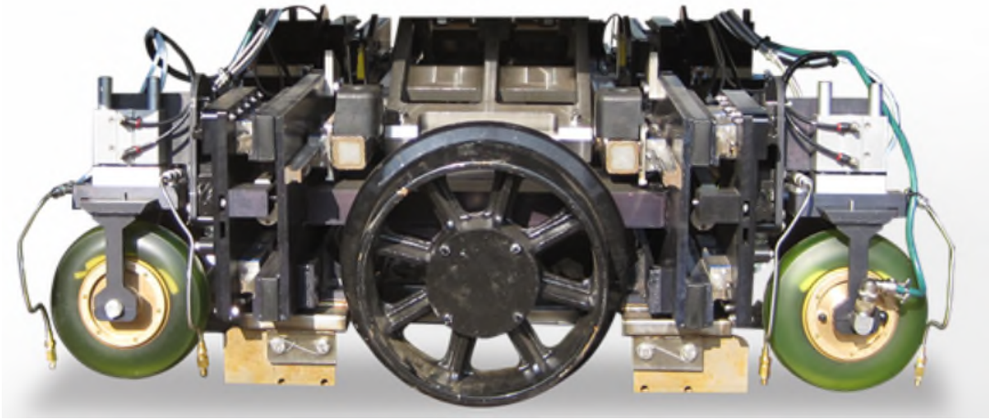
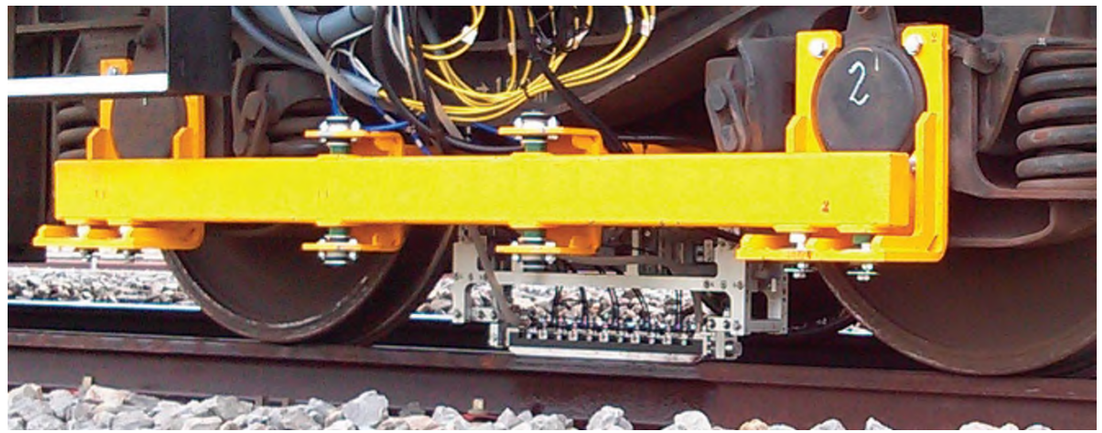


Image from Nordco
http://www.nordco.com/products-catalog/inspection-technologies/rail-bound-inspection-systems/rail-bound-rail-flaw-inspection-system-.htm

Exampled Sled Probe System
(Most Commonly Used in Europe)



ScanMaster
http://scanmaster-irt.com/wp-content/uploads/2015/11/TrackMaster-High-Speed-brochure.pdf

Vehicle Platforms:

Railbound Manned

Hi-Rail Manned

ATV Manned

B-Scan

Composite of multiple sensors to better visualize the flaw

A-Scan

Individual Sensor

Image from Nordco
http://www.nordco.com/products-catalog/inspection-technologies/vehicle-inspection-systems/NRS-260-Prime.htm

Cracked Wheel Detector

Image from Proceedings of 2018 AAR Review Matthew Witte, " Effectiveness of Cracked Rim Detectors to Identify Broken Wheels"

Example Plunger Probe System

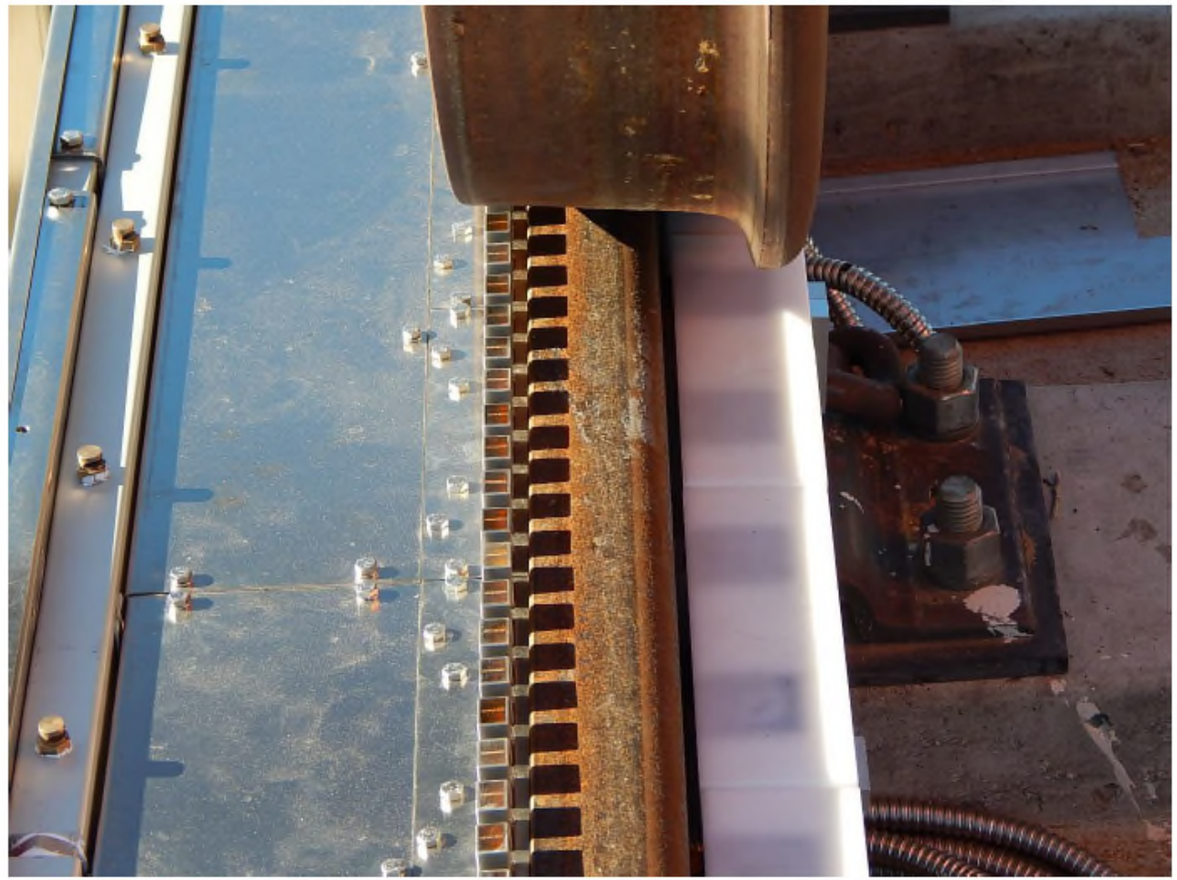


Image from Proceedings of 2018 AAR Review Matthew Witte, " Effectiveness of Cracked Rim Detectors to Identify Broken Wheels"

Example Robotic System

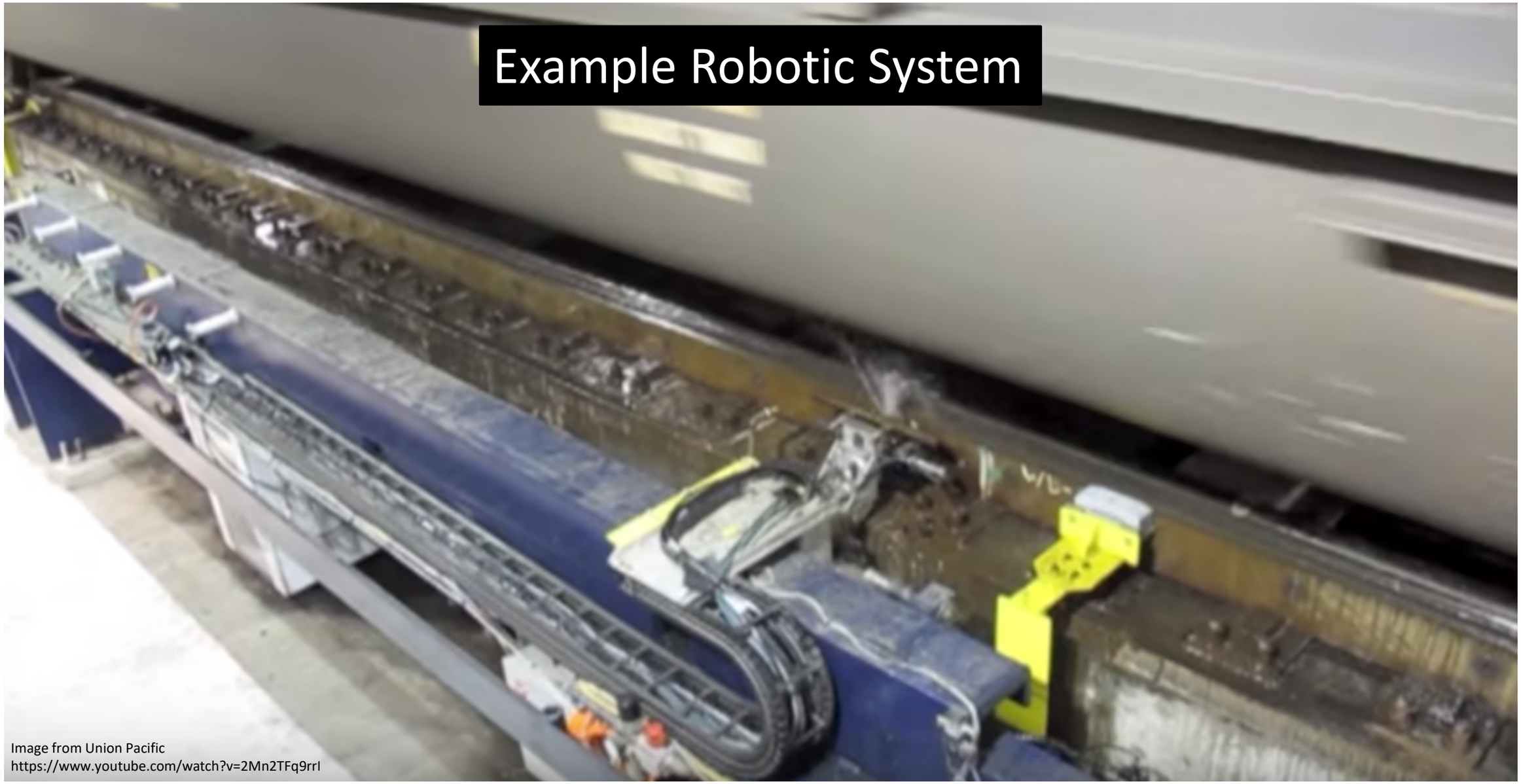


Image from Union Pacific
https://www.youtube.com/watch?v=2Mn2TFq9rrI

Example Robotic System

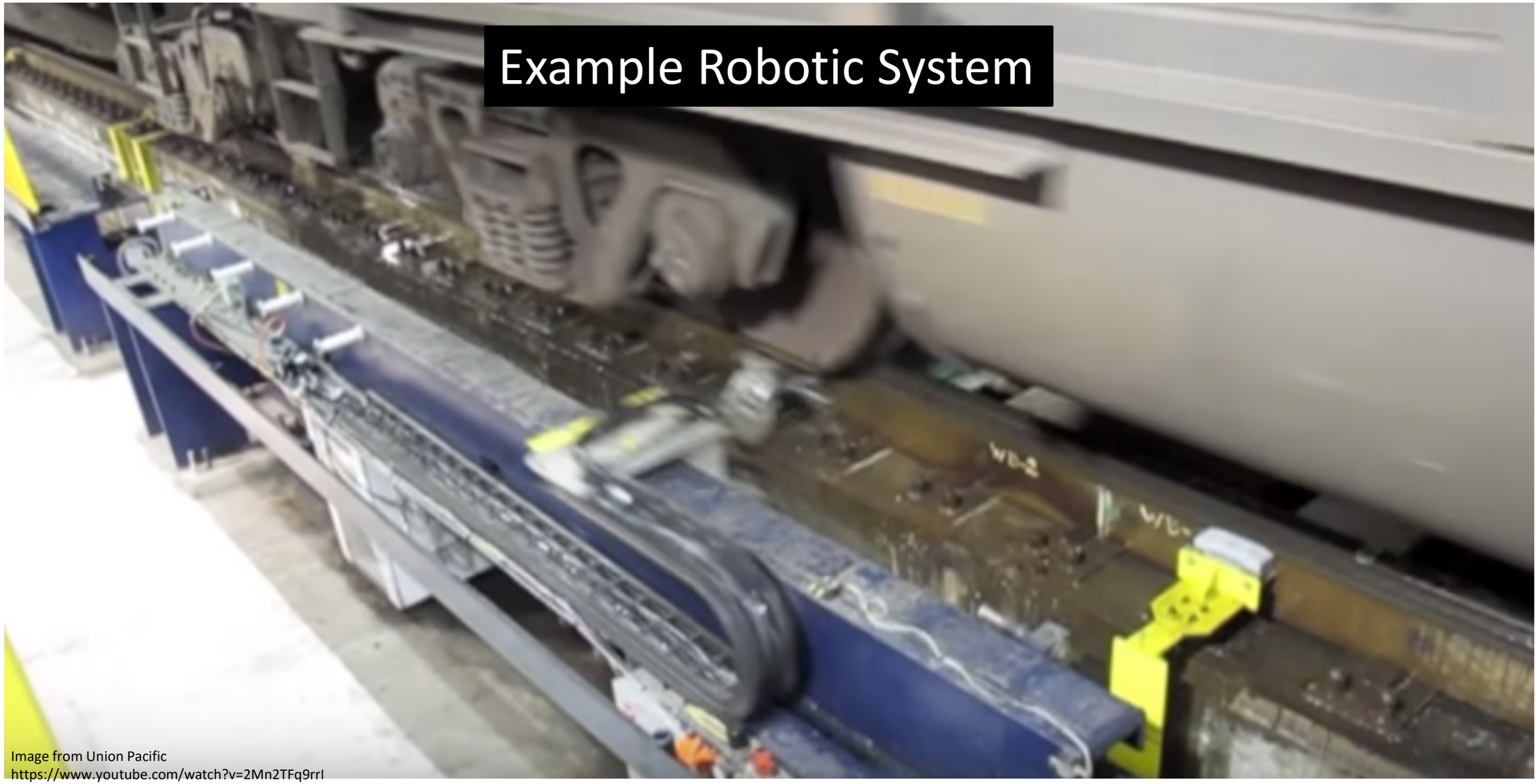


Image from Union Pacific
https://www.youtube.com/watch?v=2Mn2TFq9rrI

Imaging

Cameras

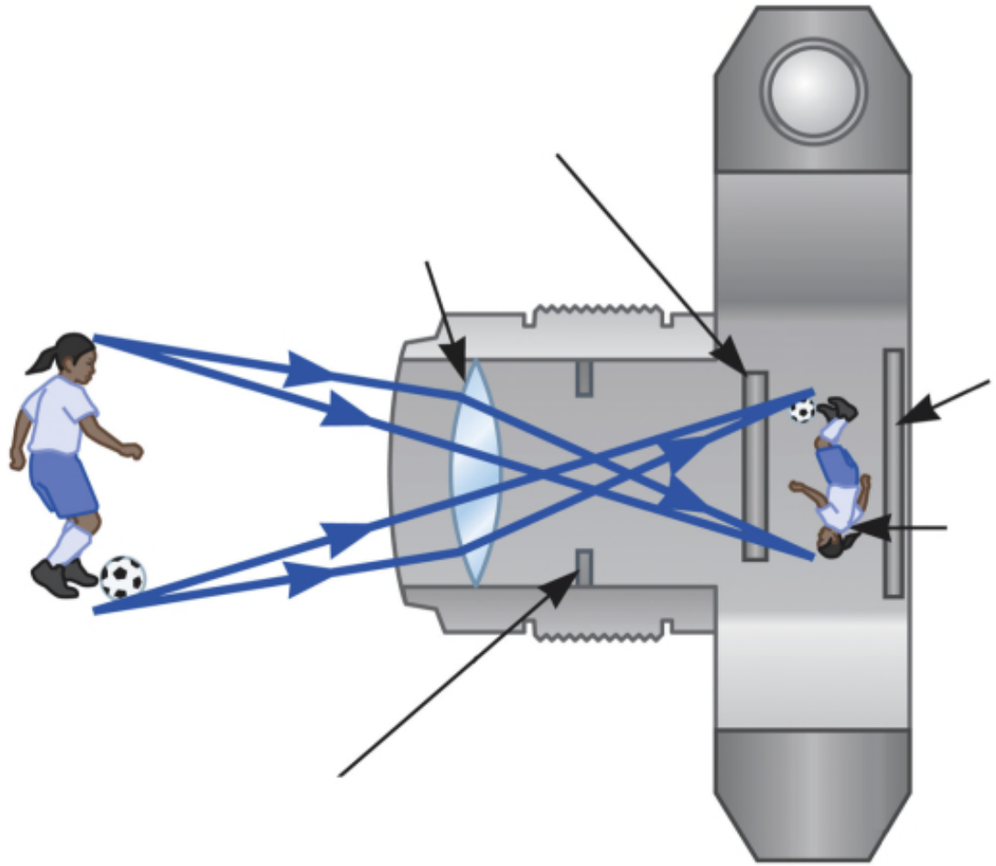
“Line Scan” Cameras
aka “Slit Scan”

Works like your document scanner

“Area Scan” Cameras
aka “Full Frame”

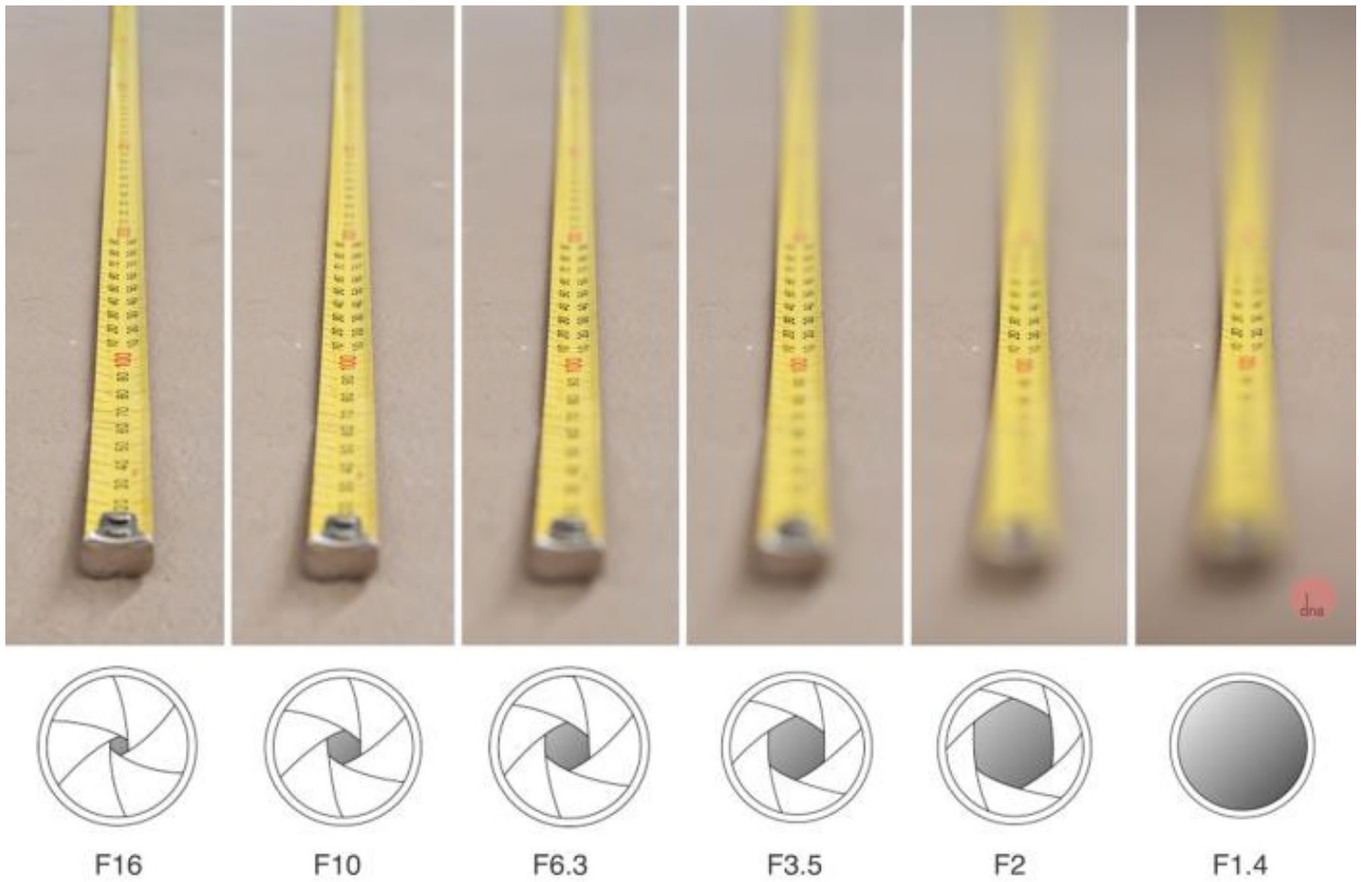
Works like your standard camera

Cameras



Ref: http://www.physics.byu.edu/faculty/colton/courses/phy123-fall12/warmups/jitt30a.html

Cameras



Ref: https://www.ormsdirect.co.za/blog/2012/05/08/what-is-aperture-desmond-louw-explains/

Cameras

What is needed for a railroad application:

Ideally want **large depth of field (small aperture)** for maximum content in focus.

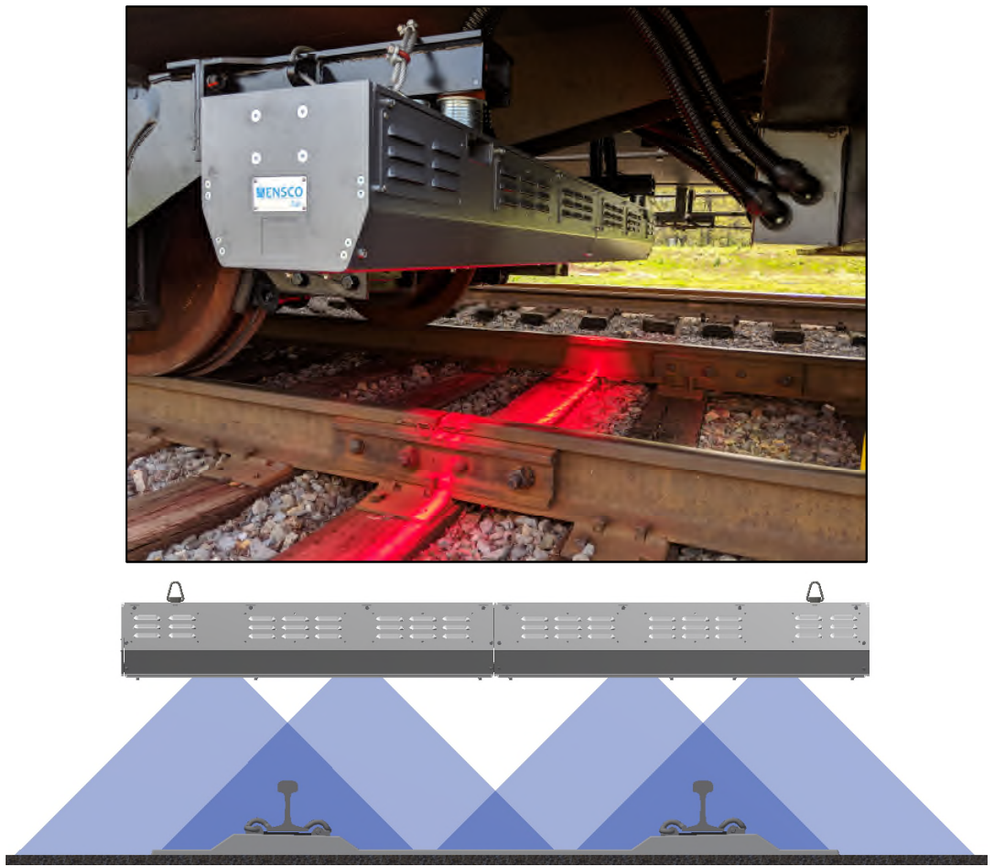
Want **fast shutter speed** to capture quickly moving objects.

Generally **need lots of light**.

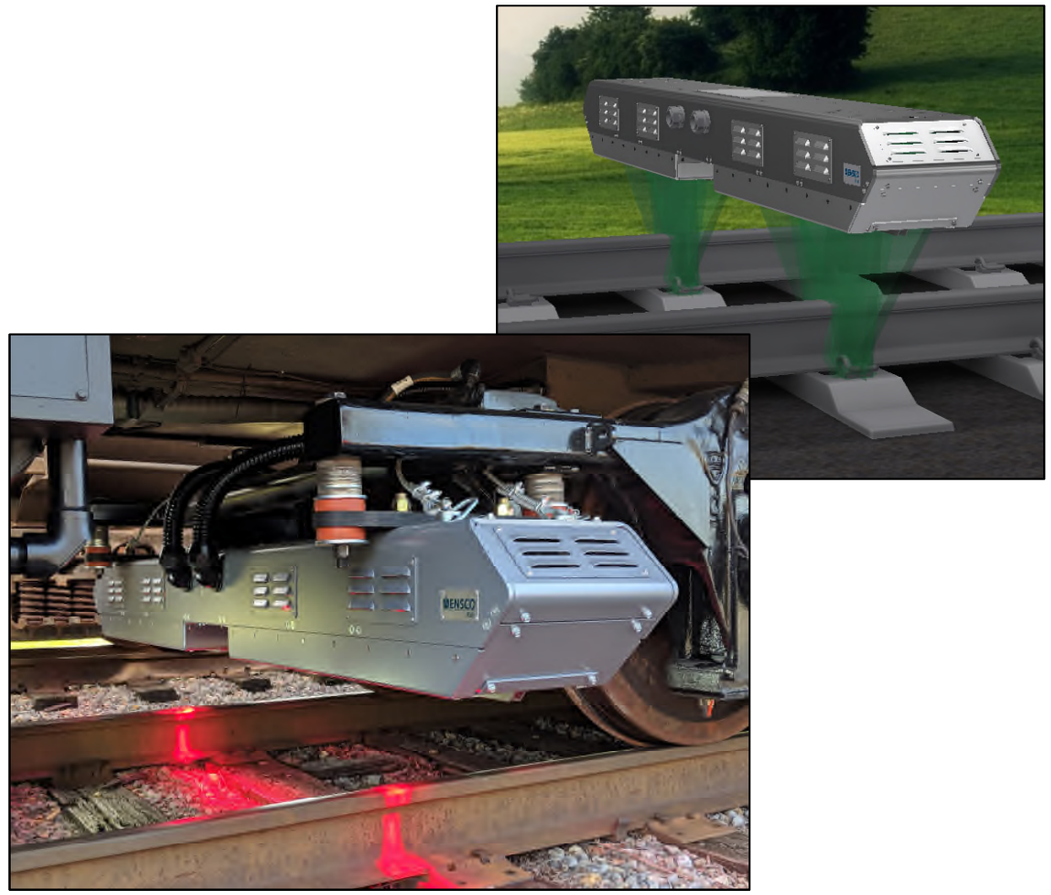
Example Camera Systems

Wheel Sensor

Example Camera Systems

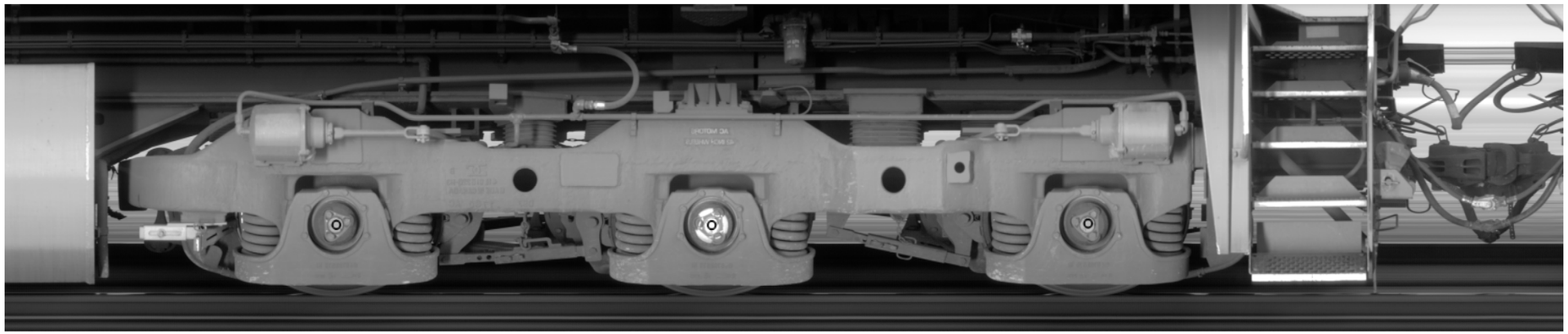


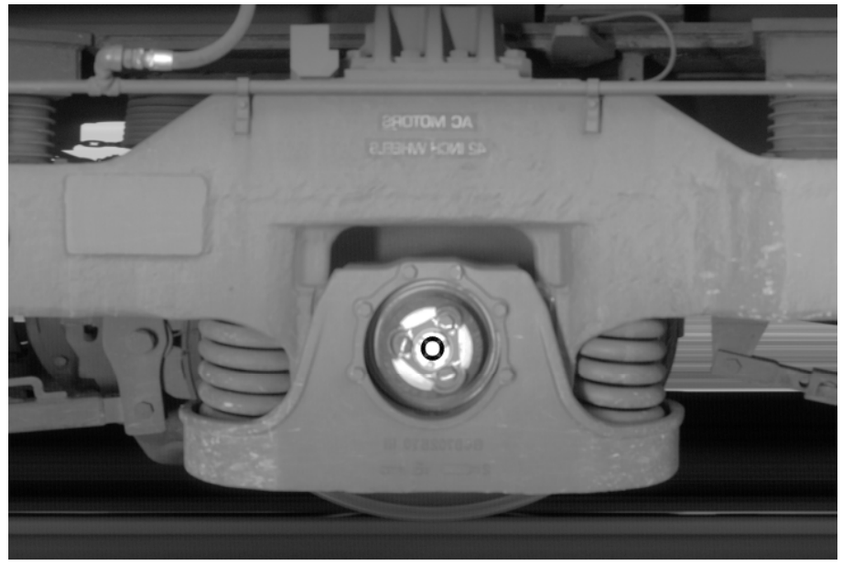
Track Component Imaging



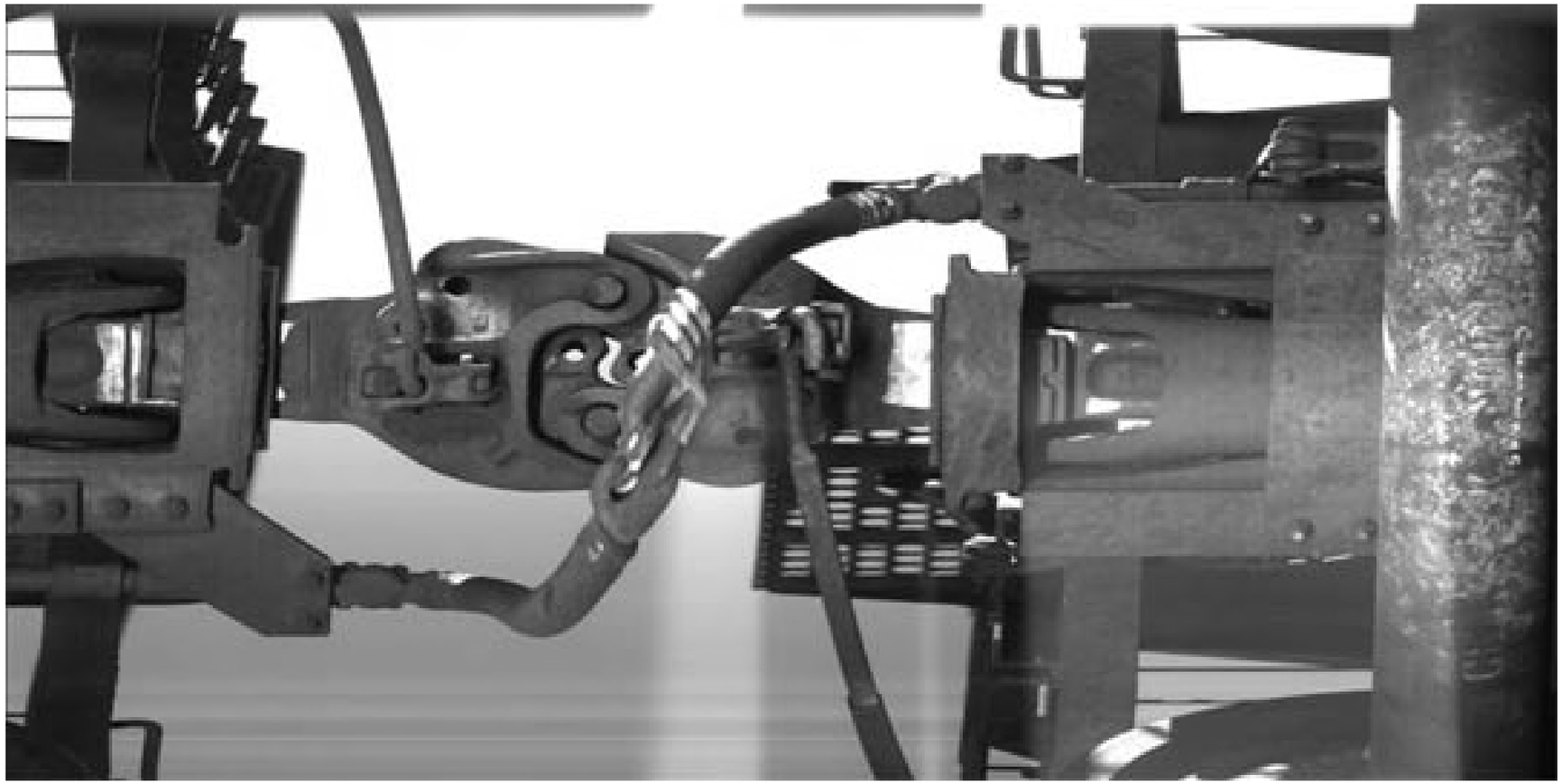
Joint Bar Imaging

Example Line Scan Images

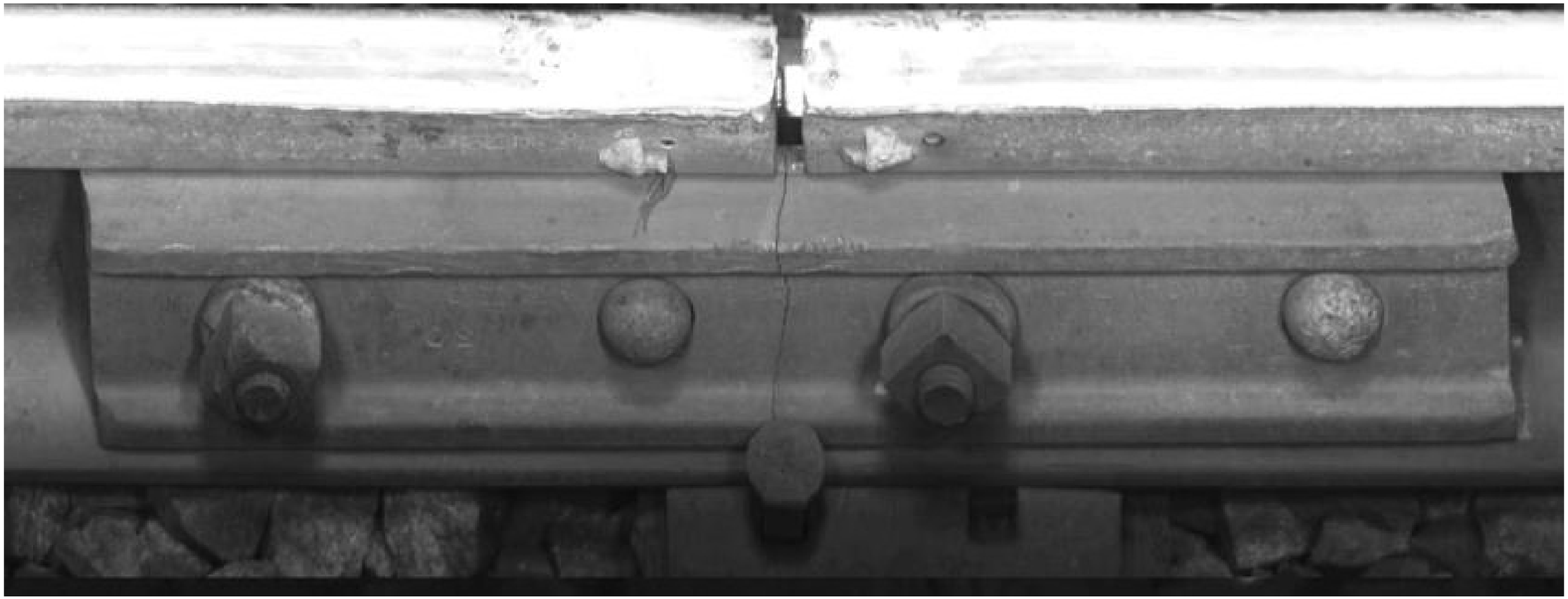




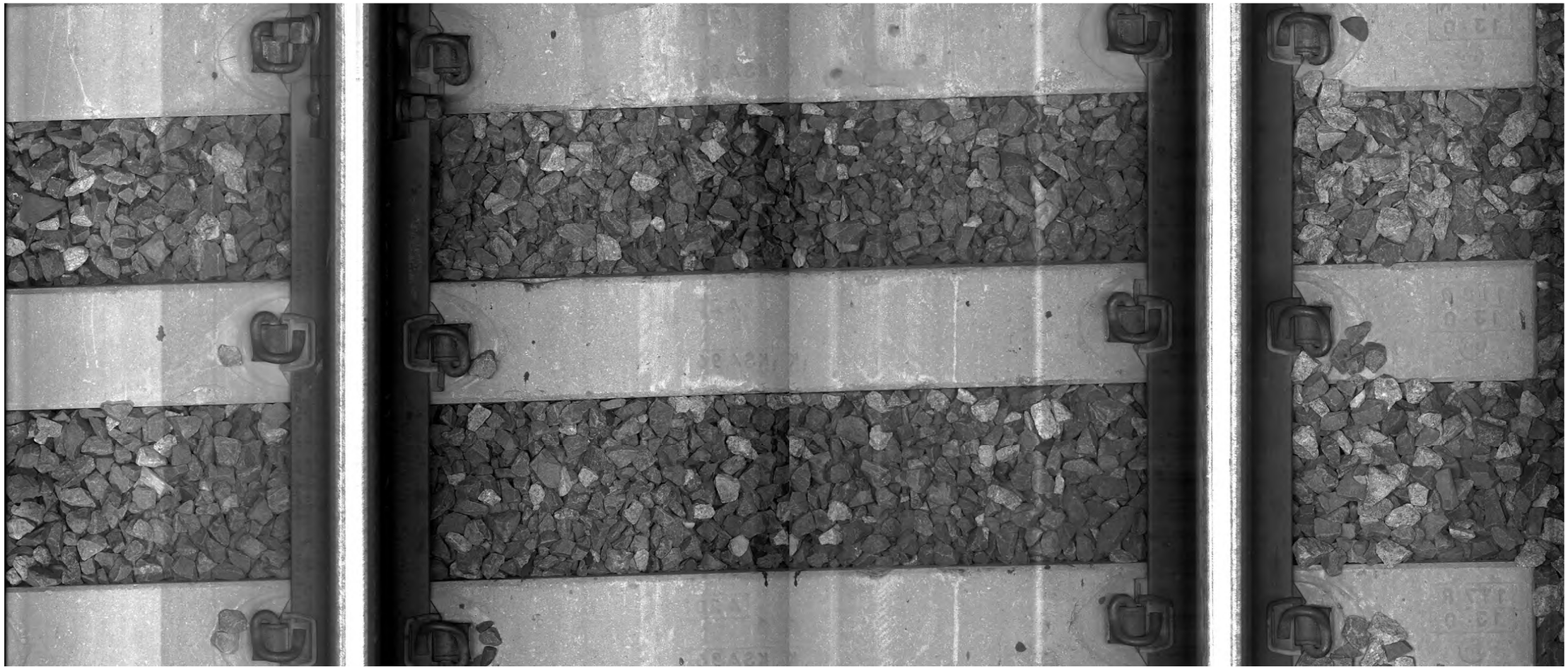
Example Line Scan Images



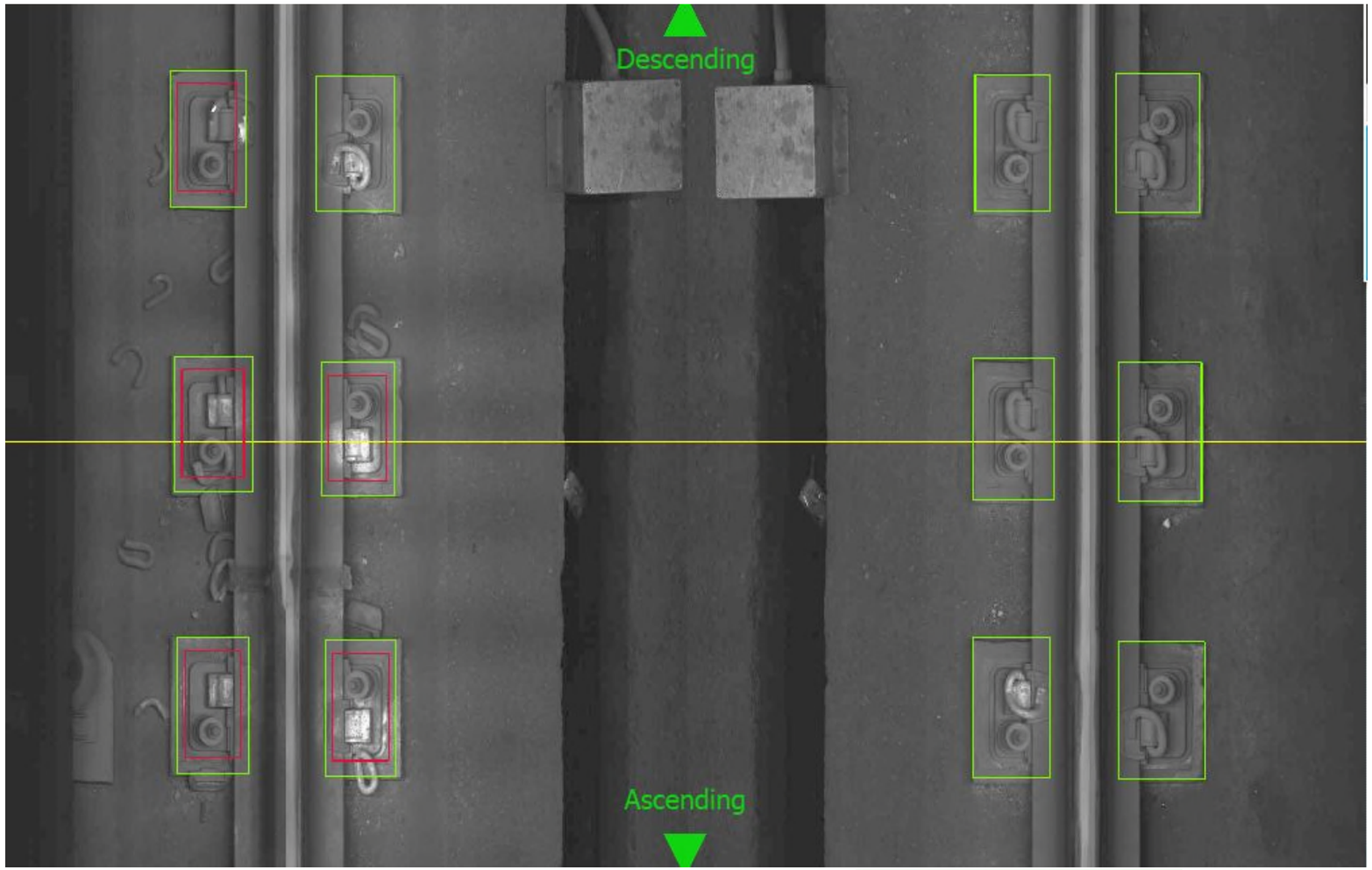
Example Line Scan Images



Example Line Scan Images

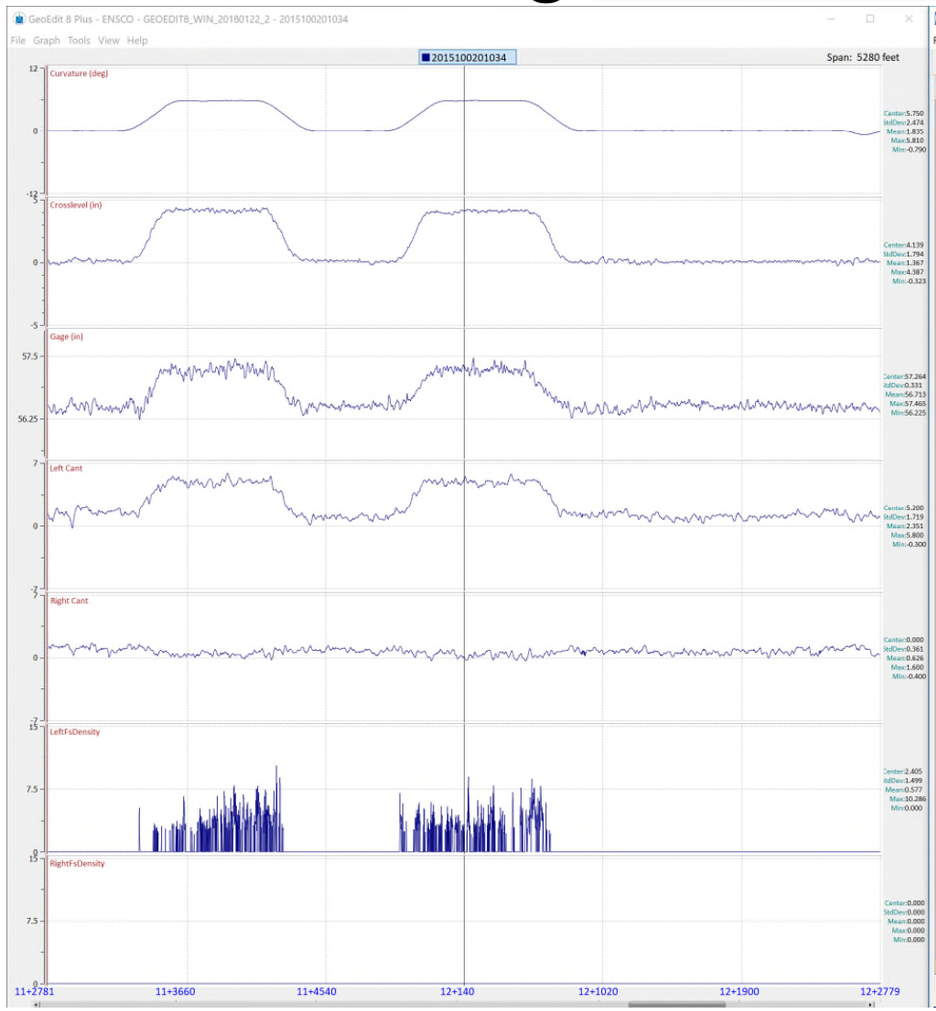


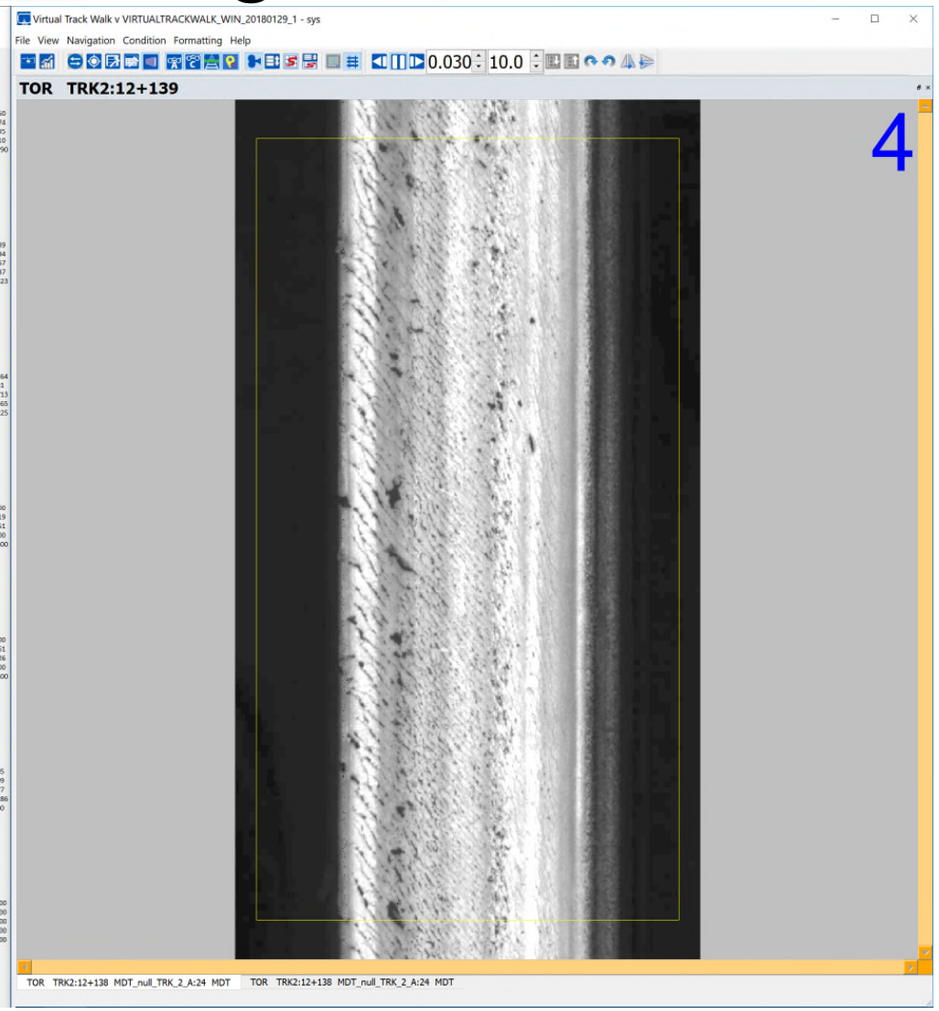
Example Automated Exception Detection using Line Scan Images



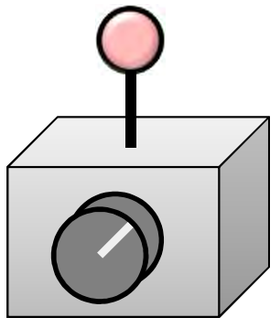
Example Automated Strip Chart Generation using Line Scan Images

- Curvature (deg)
- Crosslevel (in)
- Gage (in)
- L Cant (deg)
- R Cant (deg)
- L FS Crack Density
- R FS Crack Density

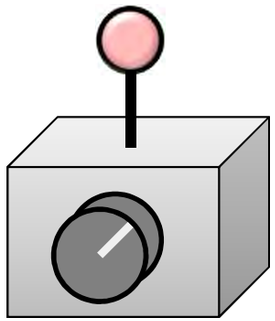




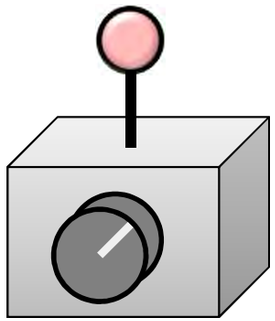
Asset Management



System identifies problem when measurement **exceeds threshold** and transmits direct to field personnel for repair.



I want to know this ahead of time to plan better!



Am I spending my maintenance funds the best?

Asset Management

Data Validation & Correction

Asset Assignment

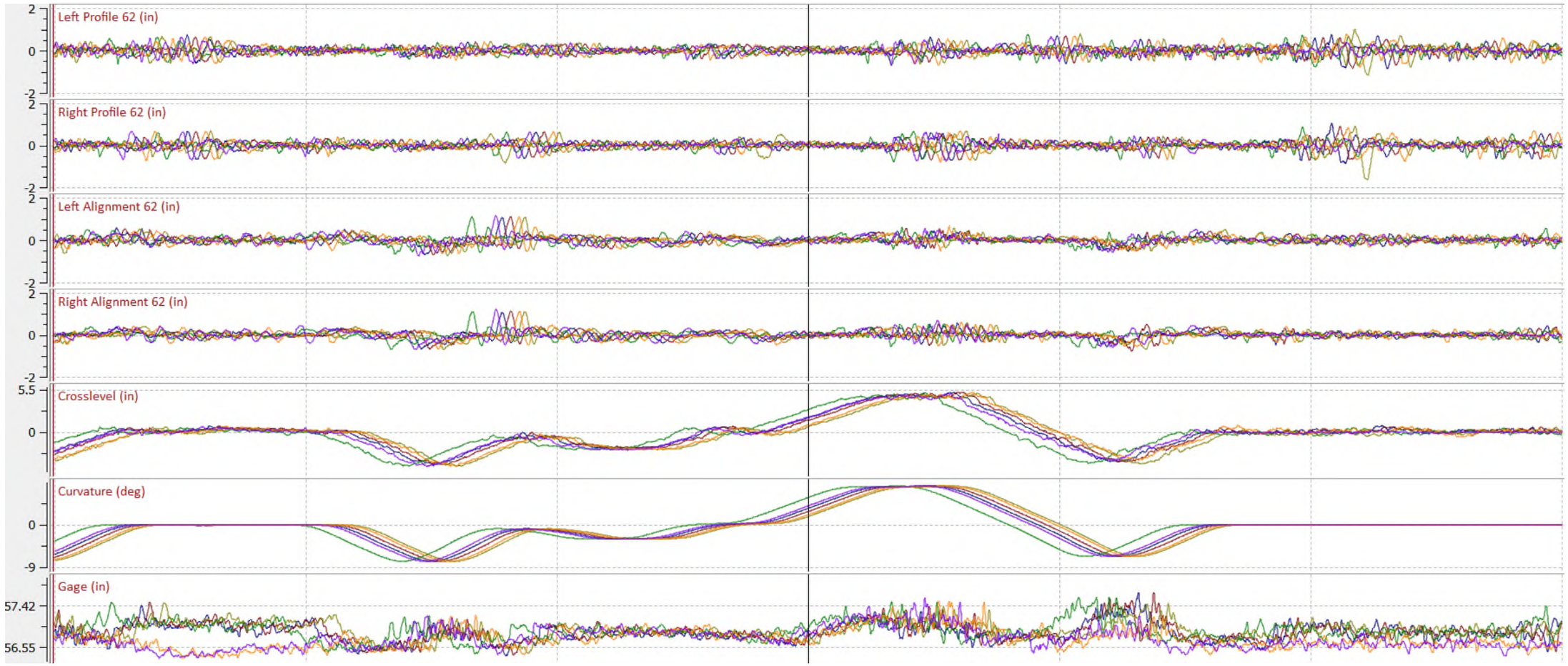
Prediction & Work Identification

Resource Planning

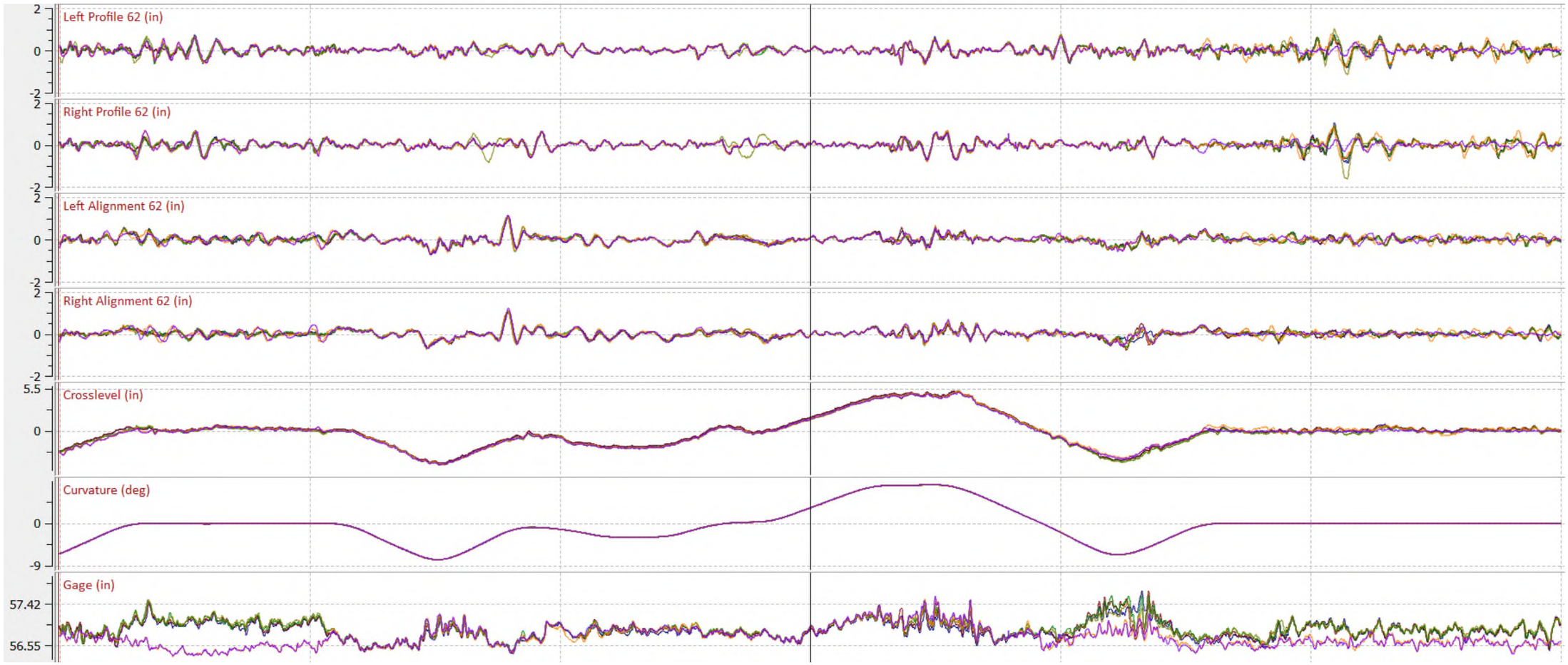
Data Validation & Correction

- We’re using measurement like we haven’t before.
- This requires a greater need for data accuracy!
  - Erroneous Data Removed
  - Profile Template Matching
  - Data Alignment

Data Validation & Correction

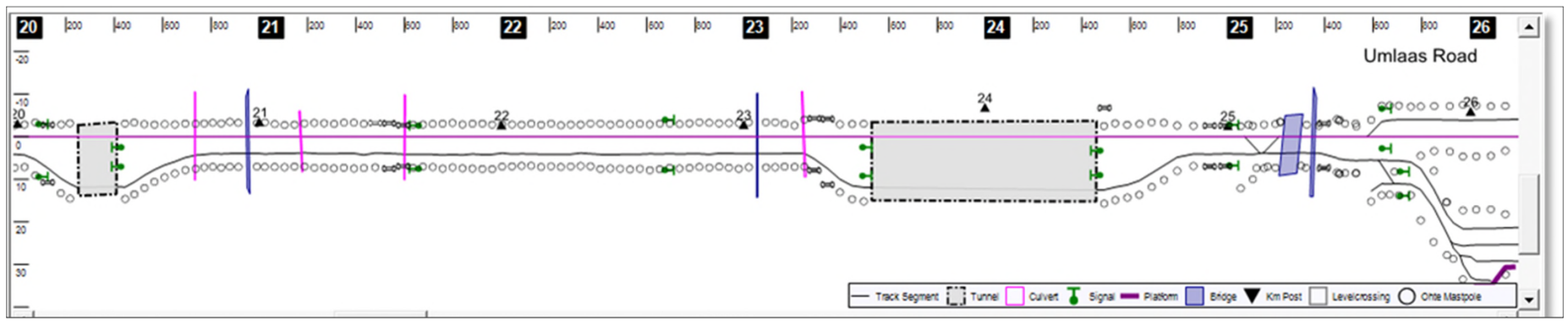


Data Validation & Correction



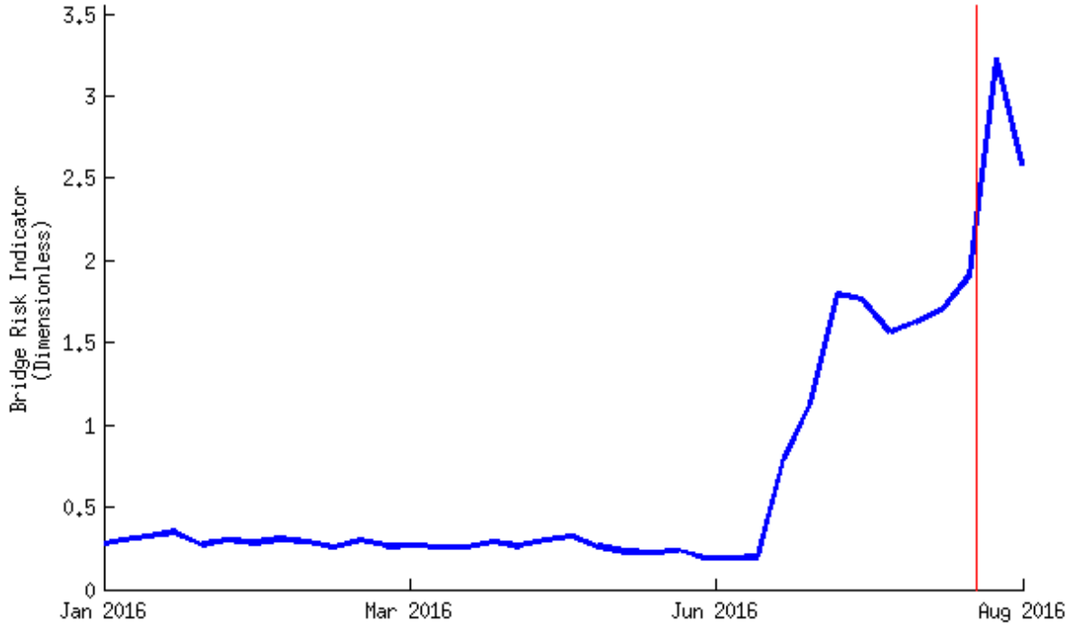
Asset Assignment

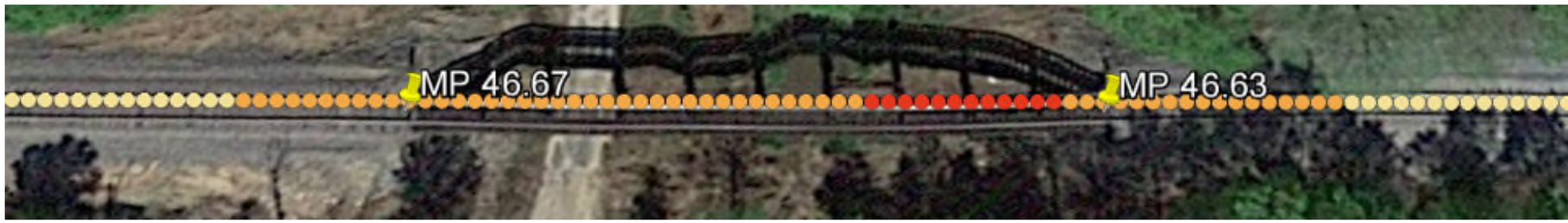
- First: What and where are your assets?
- Second: Assign data to the correct asset.



Prediction & Work Identification

- If #1 and #2 are done well, #3 is much easier!
- Prediction needs to be prescriptive as much as possible



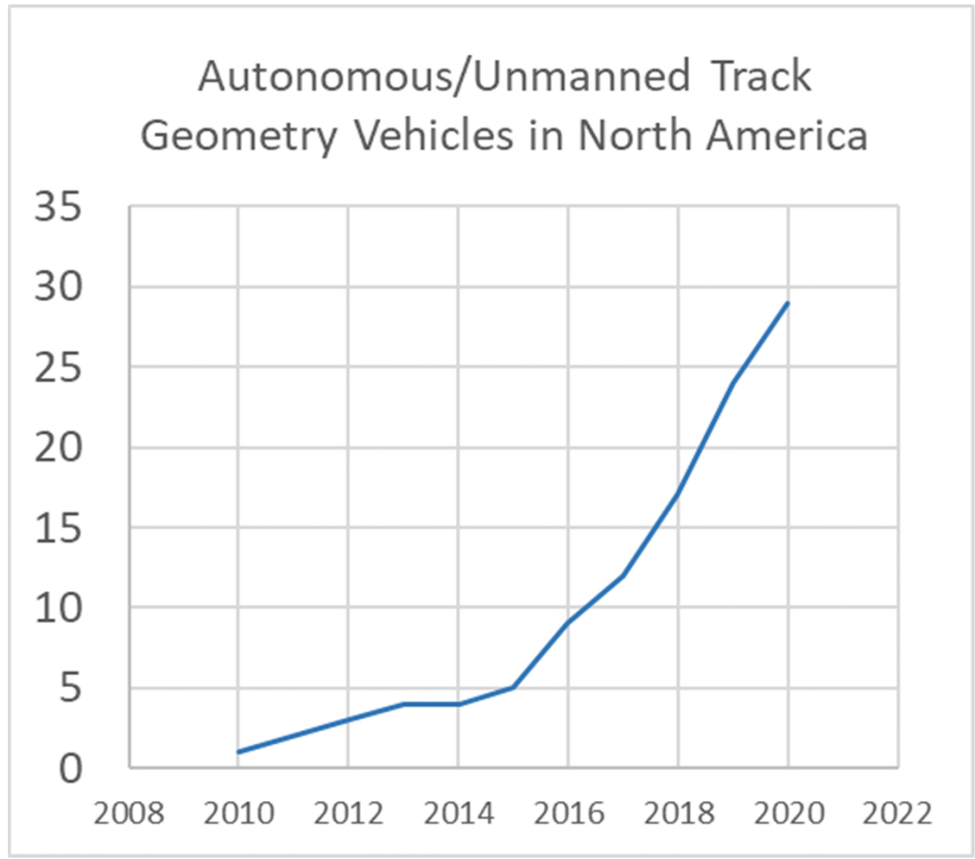


4 Resource Planning

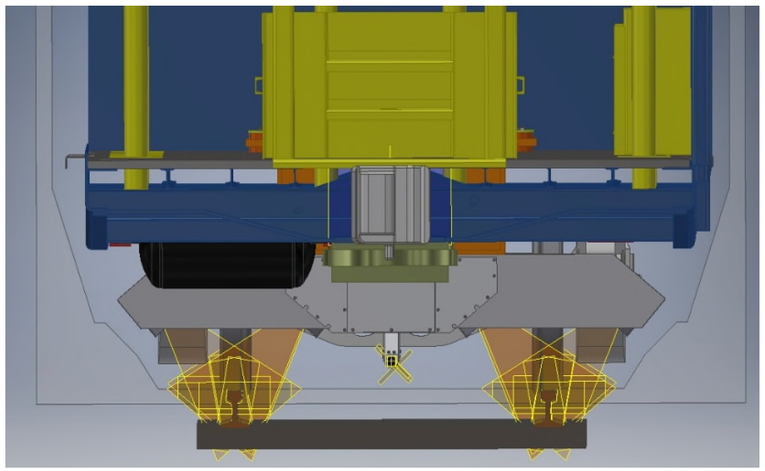
- Receive the Identified Work associated to Assets.
- Execute the Work with Work Orders.
- Linear Asset Management (LAM)

The Future is Here

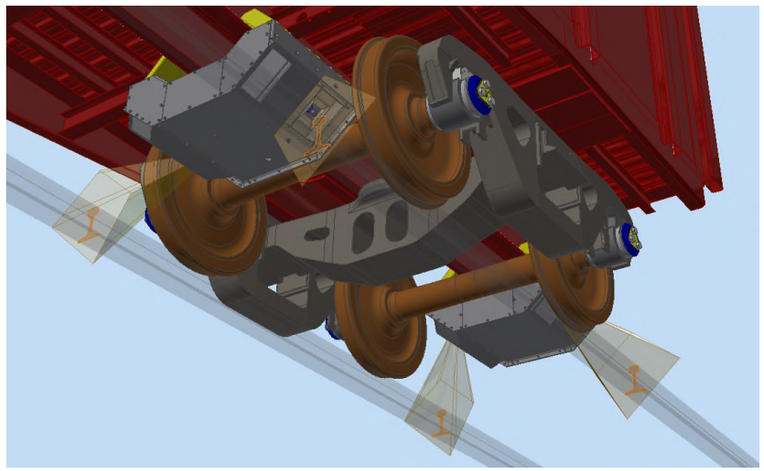
1) Autonomous Track Inspection



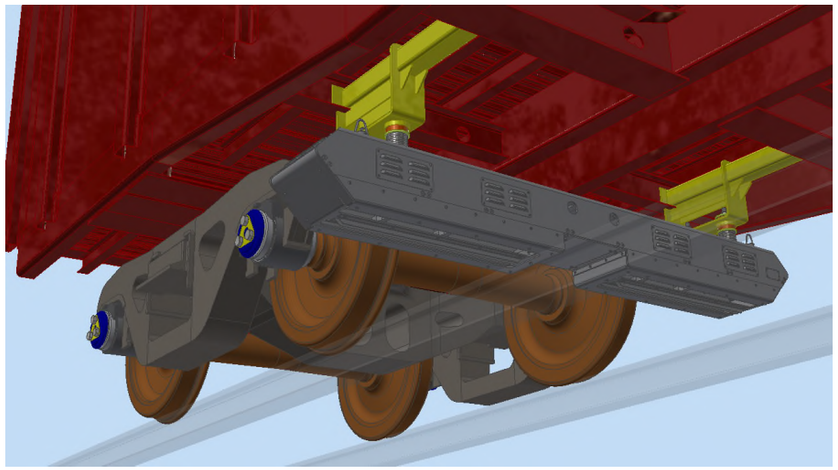
1) Autonomous Track Inspection



Carbody Mounted Autonomous Rail Profile



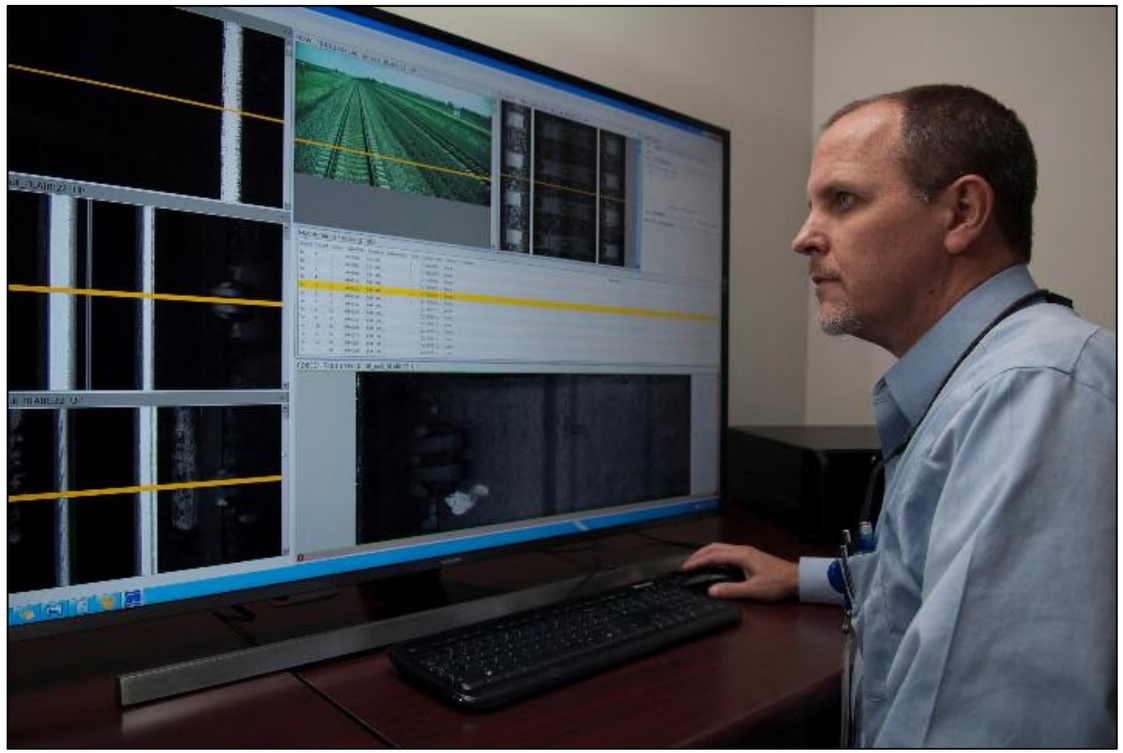
Carbody Mounted Autonomous Zero Speed Track Geometry



Carbody Mounted Autonomous Joint Bar Imaging

2) Field Inspections in the Office

Track Inspection



Train Inspection

Ref: https://beenavision.com/TrainWatch.php

Questions?