Why & How Railways Measure Track & Vehicle

by

Ryan McWilliams

International Engineering

TECHNOLOGY & GLOBAL CONNECTIONS

RailAdvisor.com

Pueblo, Colorado

Primary Purpose of Measuring & Monitoring: To Prevent loss of life and loss of $$'s
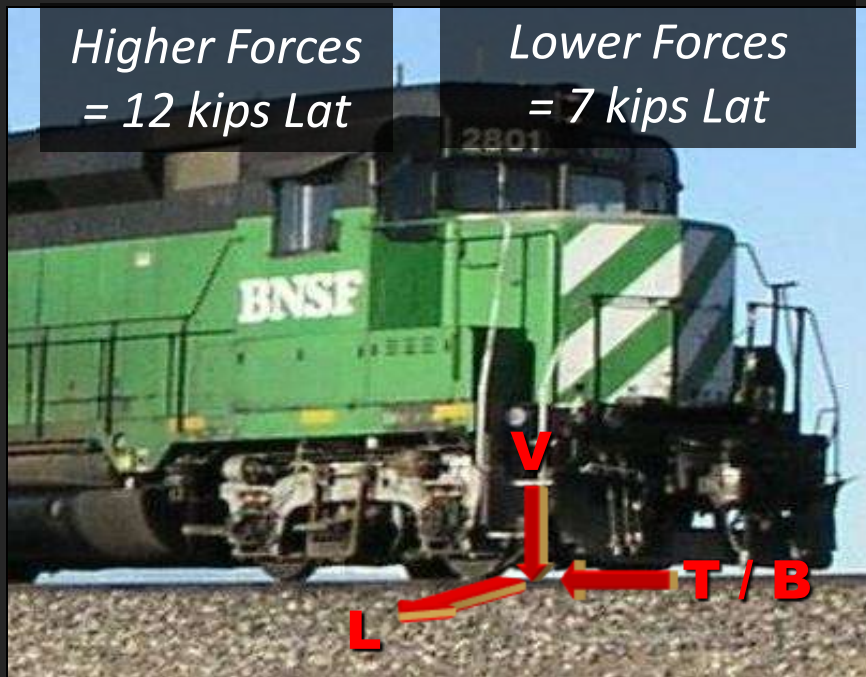

$2.1 Million USD Cleanup + bad PR & Claims

7 Killed

Industry Approach to Performance Monitoring

Reduce the Stress State = Lower Forces

Higher Forces = 12 kips Lat

Lower Forces = 7 kips Lat

V

L

T / B

Strengthen &/or Improve All Systems

Standard 260 = RCF Observed

Head Hardened = Less RCF Observed

Measure & Manage

Approach to Performance Monitoring
(Performance Monitoring Based Approach)

Monitor Infrastructure & Rolling Stock Through Network of Detectors

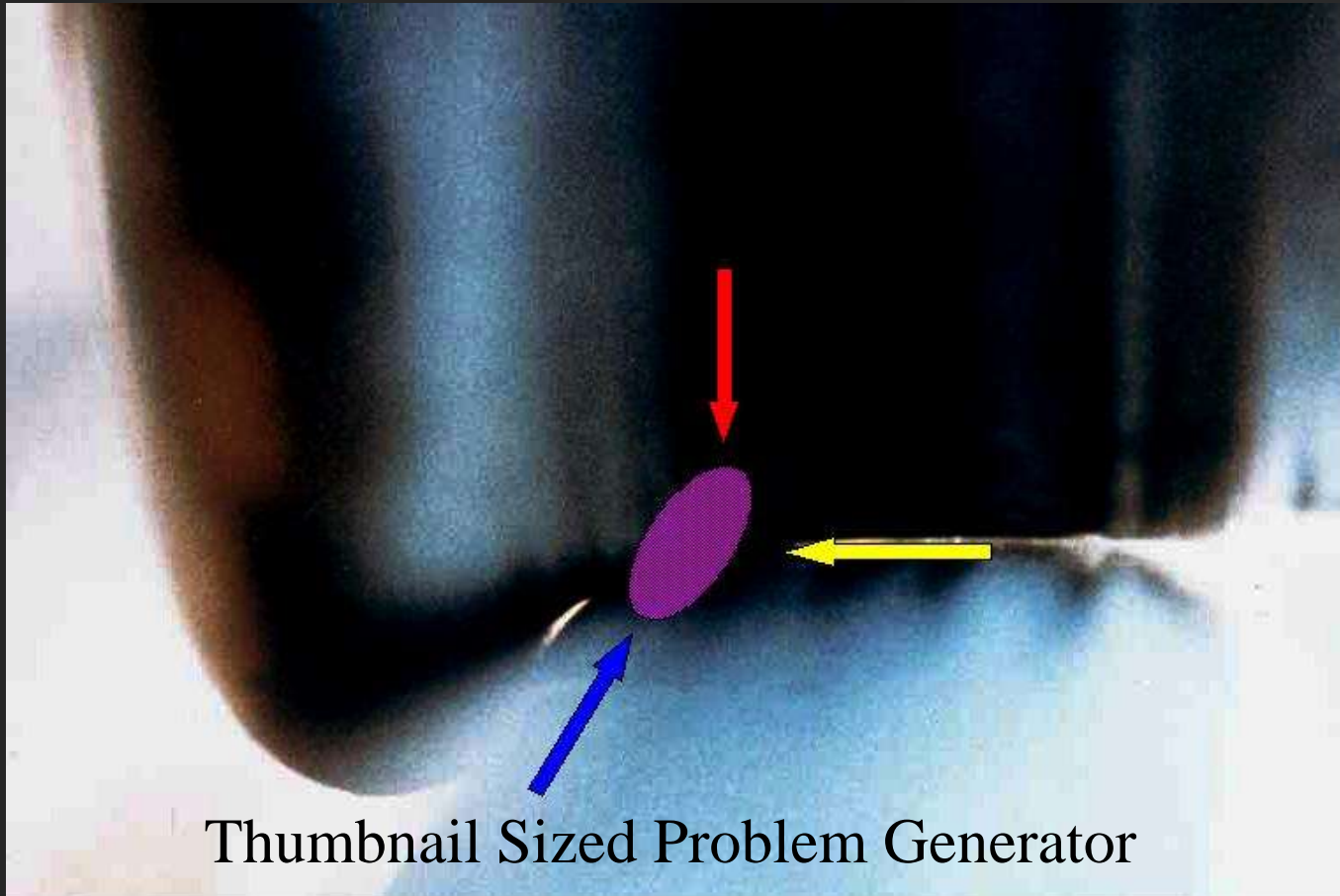Process Real-Time Data & Forward Actionable Information to Operators

Reduce In Service Failures, Improve Safety & Increase Performance

Who Owns & Manages the Contact Patch?

- This is both a Company Asset as well as an Industry Asset
  - Two owners?   No Owners?

Thumbnail Sized Problem Generator

Wheelsets command a high % of the wagon/car maintenance budget

Wheel tread

Wheel bearing

Wheelset

Truck

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Monitoring Systems in Service Today

Vehicle Systems

Wheel Profile System
Wheel Back to Back Spacing Monitor
Wheel Impact Load Detector
Acoustic Bearing Monitor
Brake Shoe Vision System
Cracked Axle Monitor
Cracked Wheel Detector
Stuck Handbrake Detector
Hot / Cold Wheel Detector
Truck Performance Detector
Hunting Truck Detector
Hot Bearing Detector

Track Systems

Tie Integrity Vision System
Fastener Position Vision System
Joint Bar Integrity Vision System
Ballast Integrity Vision System
Subgrade Monitoring (GPR)
Rail Profile Monitor
Rail Flaw Detection
Gage Corner Crack Detection
Coefficient of Friction Monitoring
Track Geometry Systems
Lubrication System Monitoring
Ballast/Subgrade Movement Detector

All Advance Our Capabilities & Knowledge

Monitoring System Basics

- **Sensors** must function in **robust** environmental conditions
  - -50°C to 60°C plus solar load, Hot / wet; high vibration, often exceeding EN standards.

- **Alerts**, based on data **trends**
  - Traditionally Alarms (to stop the train)

- **Databases:**
  - Provide data storage for **wide range** of sensors
  - Filter data through series of "**customizable**" rules based on inputs from **multiple** sensors
 - Issue Alerts, messages, reports & maintenance planning information

System Evolution (from AU)
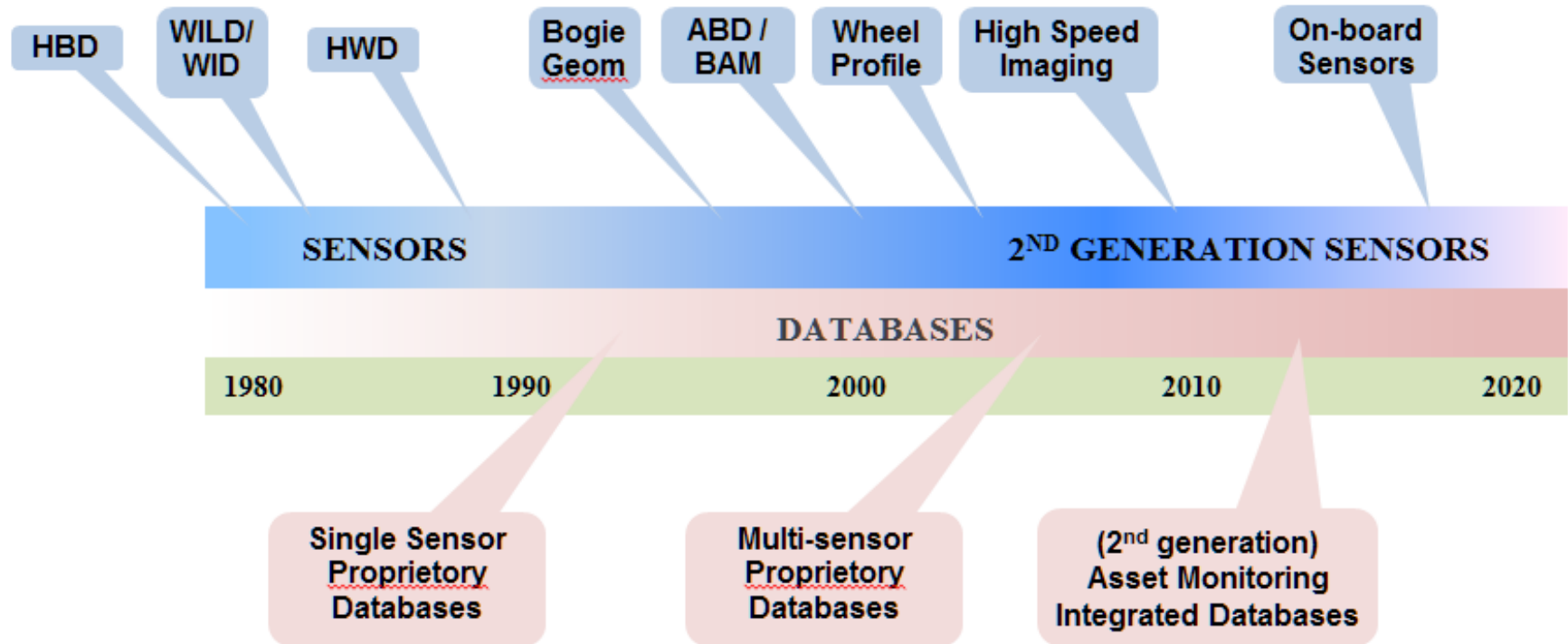
Conceptual View of Wayside Monitoring Evolution

Priorities in Condition Monitoring

- 20% of wheelsets are likely to need maintenance each year

  - *26% may have Tread Defects*
    - » *Impact*
    - » *Spalling*
    - » *Shells*
    - » *Skids*
  - *23% may have Thin Flanges*
    - » *Pulling to one side*
  - *17% normal wear*
    - » *Hollowing*
    - » *Hi Flanges*
  - *13% Bearing Defects*
    - » *Running Surface*
    - » *Looseness Fretting*
    - » *Leaking grease / Seals*
  - *21% Unclassified*

Wheel Impact

Truck Geometry

Wheel Profile

Acoustic Monitoring
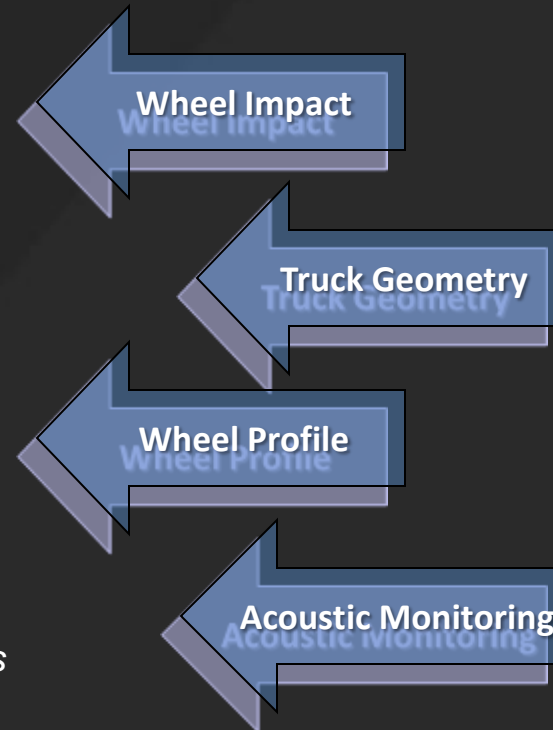
Vehicle Monitoring

Wayside & On-Board

First Monitoring System – 1940's Hot Box Detector *(Failed Bearings)*

Early Axle "Box"

Severe Burn Off – Courtesy TSBC

Started Manually: Oil smoke during the day or a red glow at night

Became Automated: Infrared Light Sensor to detect Hot Bearings

Now Spaced Throughout the NA System @ 15-25 mile intervals

Acoustic Bearing Detector (RailBAM)
from Trackside Intelligence

'Common' Bearing Defects

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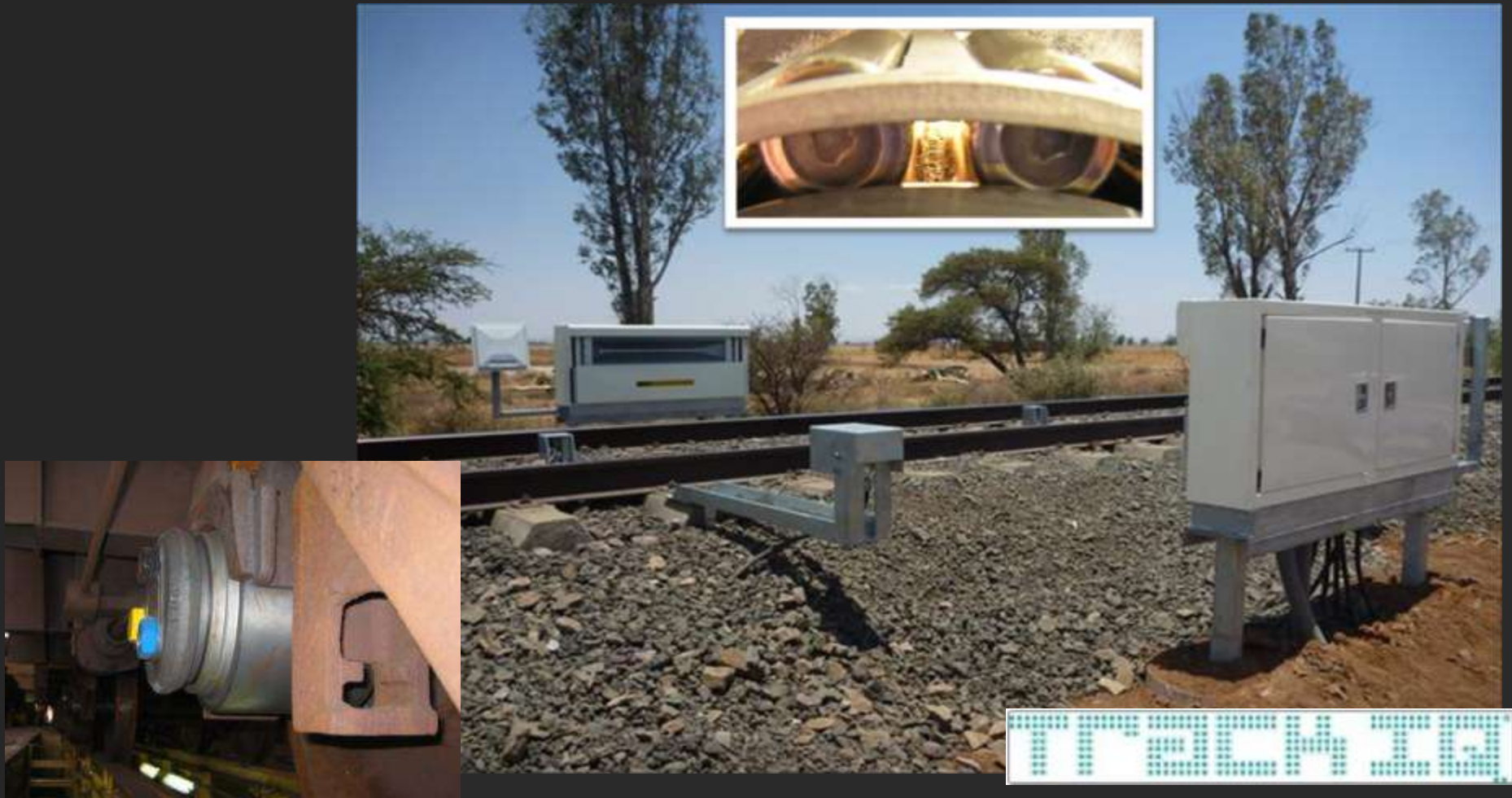
Bearing Defect Detection

- Hot & warm bearings captured using thermal imaging sensors (HABD's, HWD's) – **Reactive, last resort**

- Developing defects measured using acoustic methods (ABD's).   Want to know:
  - Defect size & location
  - Axial wear & fretting
  - Presence of worn cage slots
  - Loose cones

- Derived from acoustic signature in presence of wheel noise and other operational noise

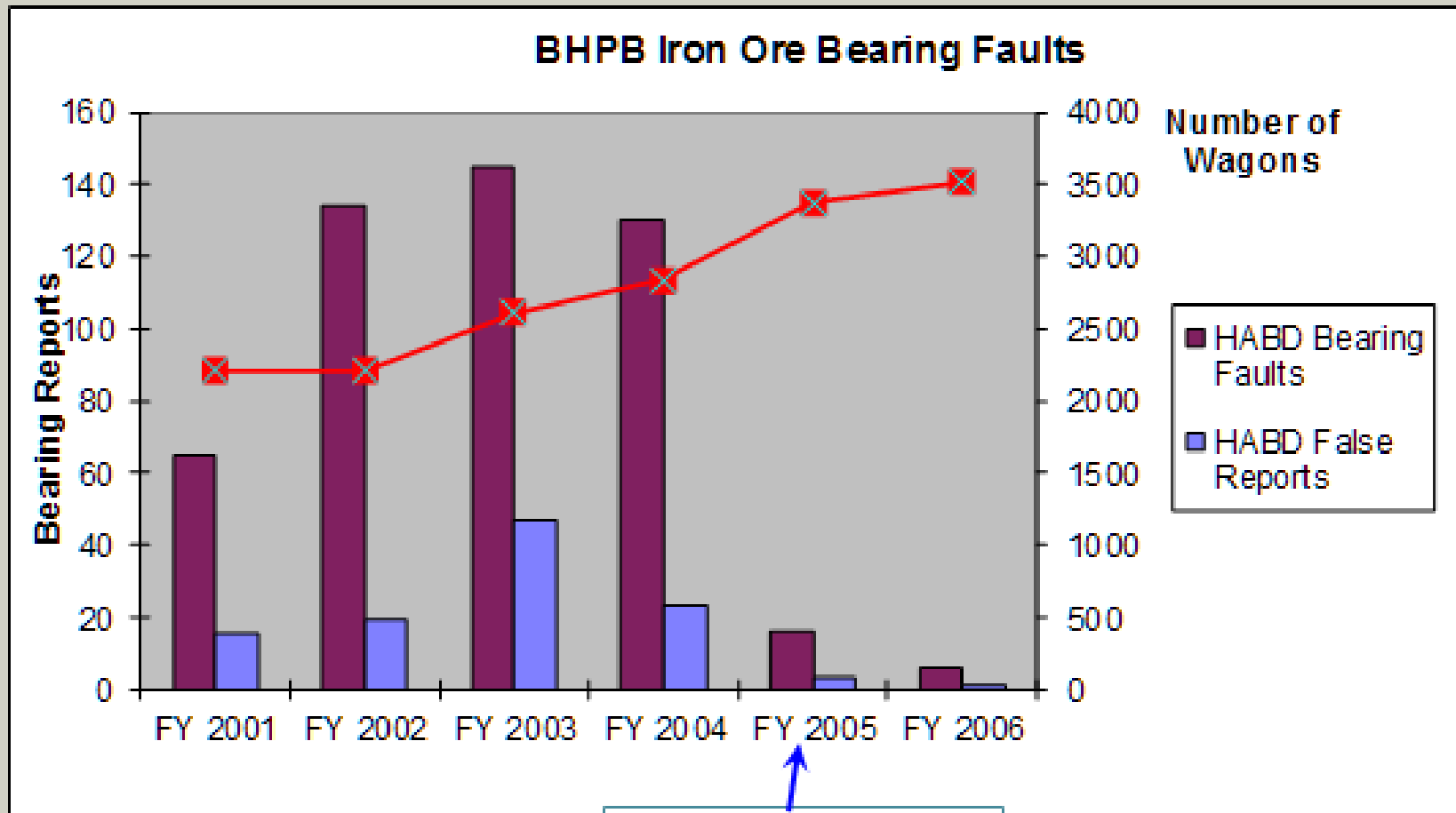# Defect Severity Progression

Level 3 / Low Severity Defect
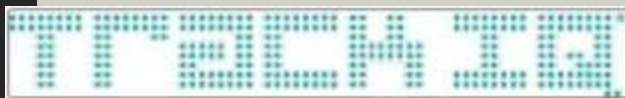

Level 2 / Medium Severity Defect
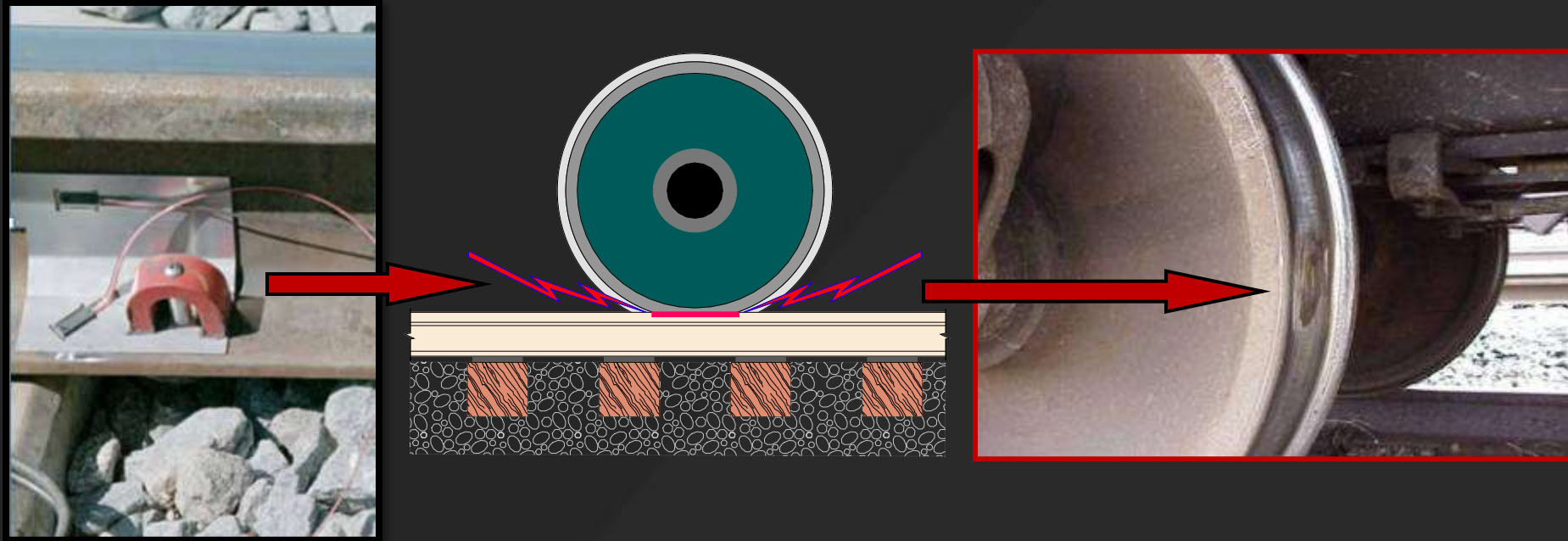

Level 1 / High Severity Defect

Heavy Haul Benefits

BHPB Iron Ore Bearing Faults
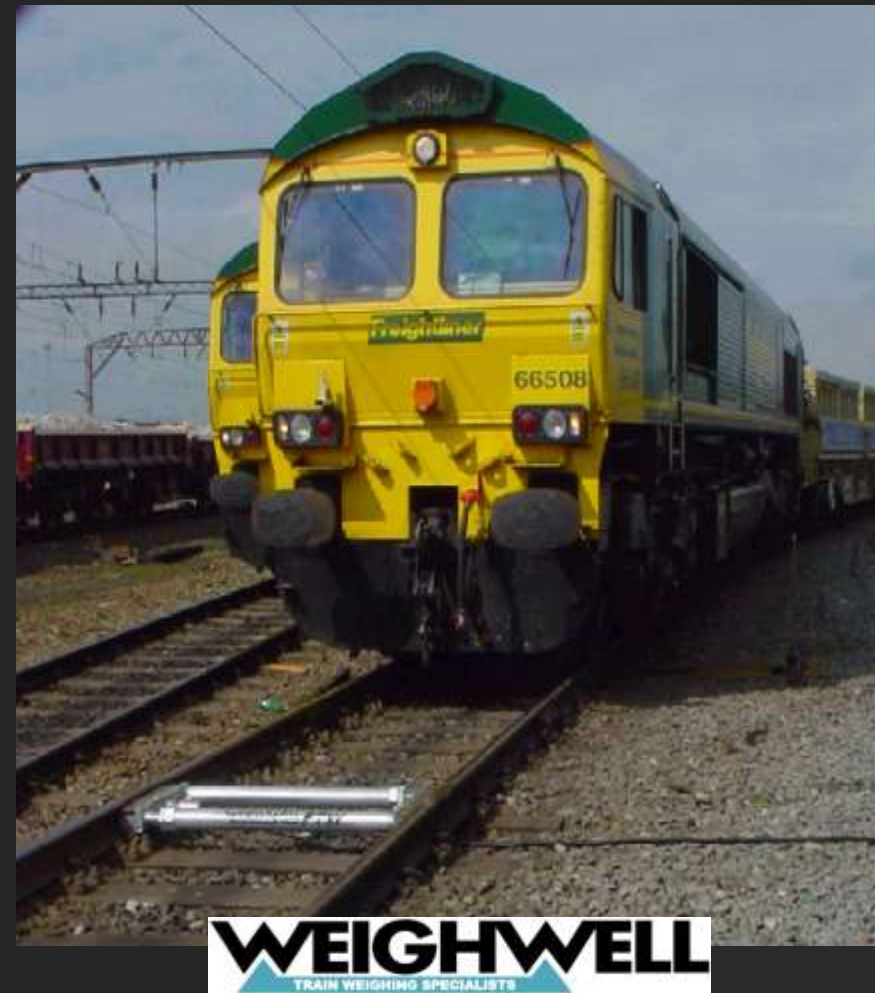
Bearing Acoustic
Monitoring
Introduced July 2004

Wheel Impact Load Detector (WILD)

WILD System Developed out of Battelle Labs in 1984 by Harold Harrison

- Became a platform for Hunting Truck, Overload & Weigh-In-Motion Detectors
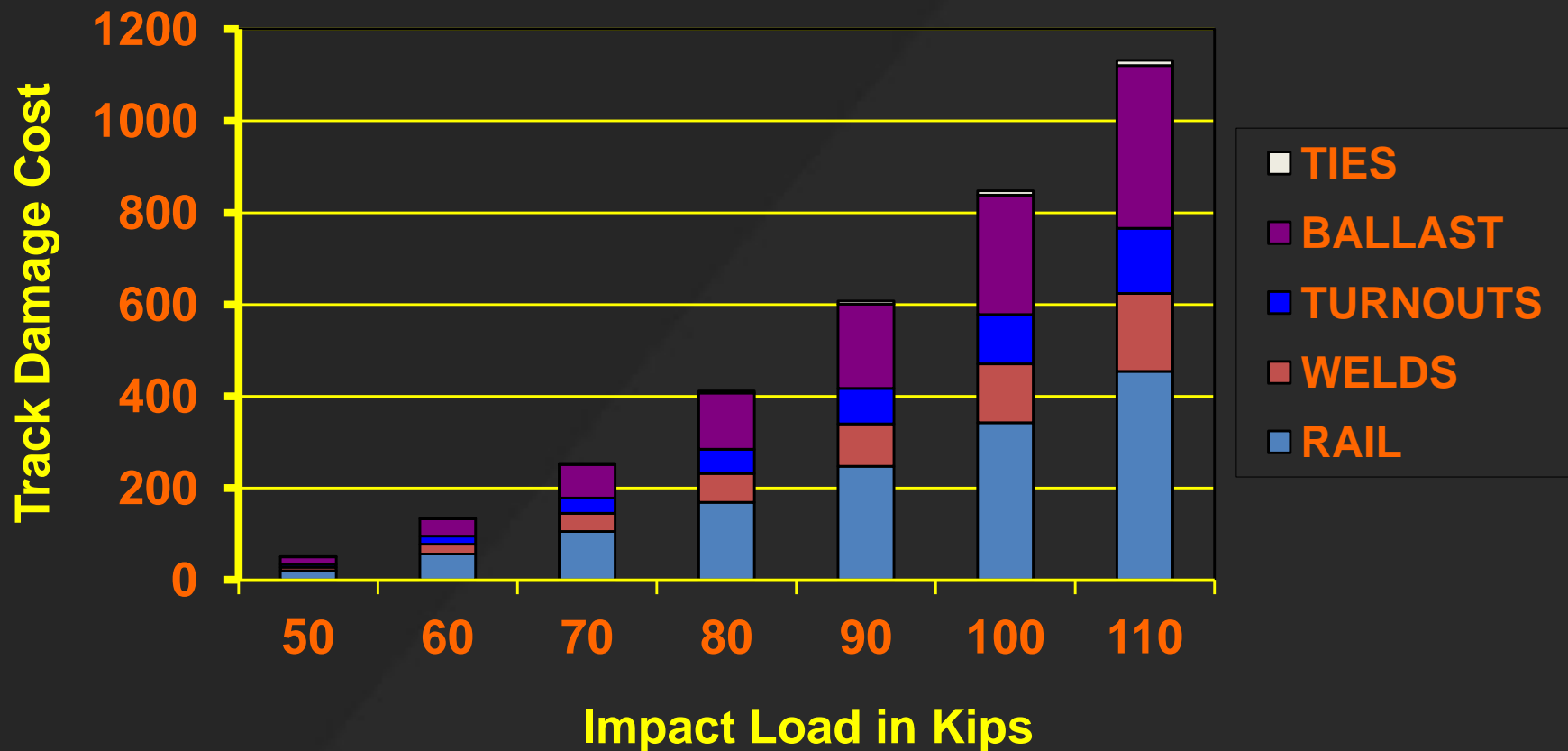
Wheel Monitoring & Weighing Systems

WEIGHWELL
TRAIN WEIGHING SPECIALISTS

Accelerometer

Load Bar

Wheel Defect Detection

Wheel Flat / Spall

Shelling

Track Component Cost vs. Impact Load from AAR – Basis of 90Kip Rule

Track Damage Cost vs. Impact Load in Kips

Legend:
- TIES
- BALLAST
- TURNOUTS
- WELDS
- RAIL

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AAR Reported WILD Efficiency Gains
Planning Wheel Repairs by Shop Location
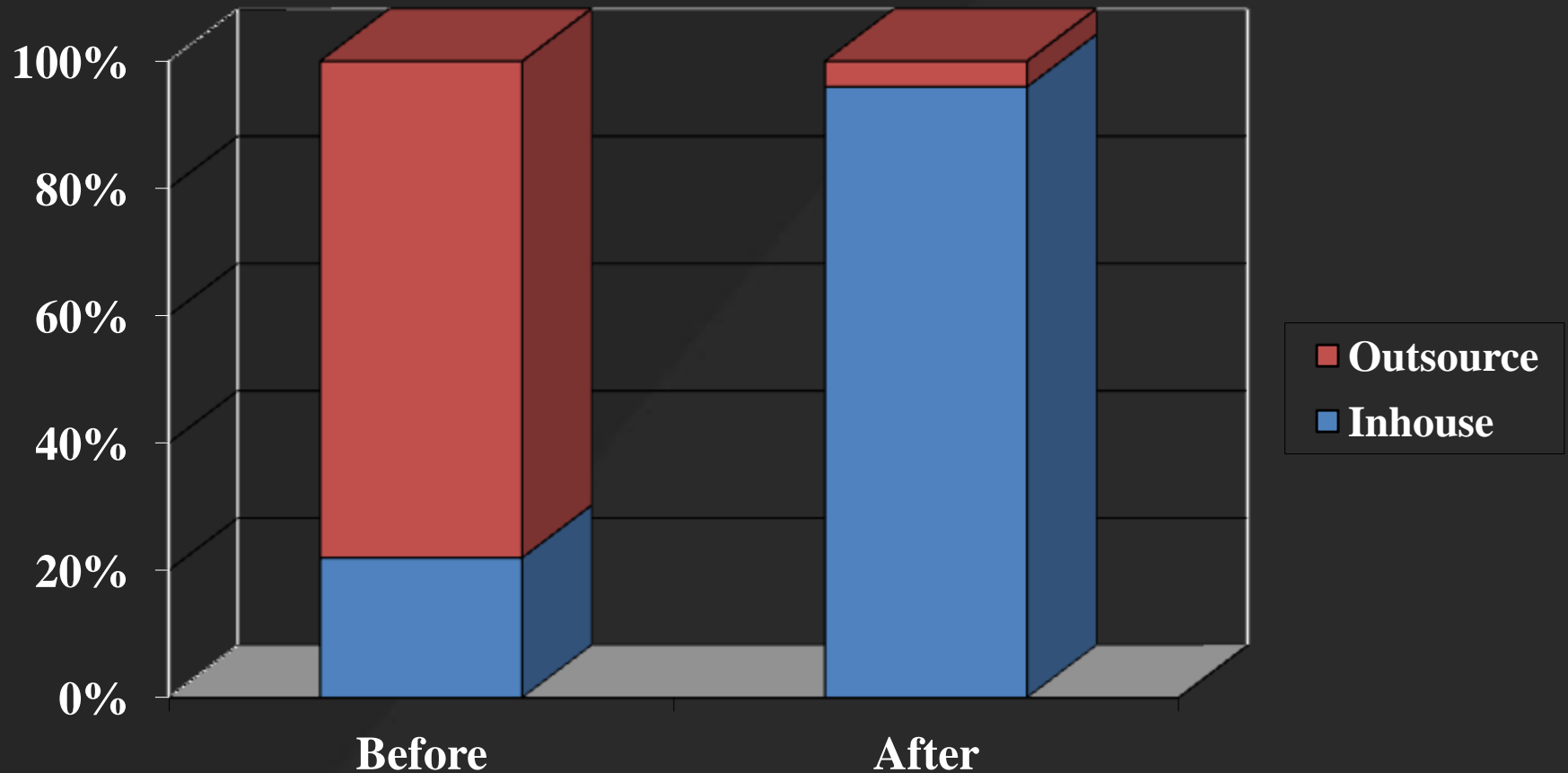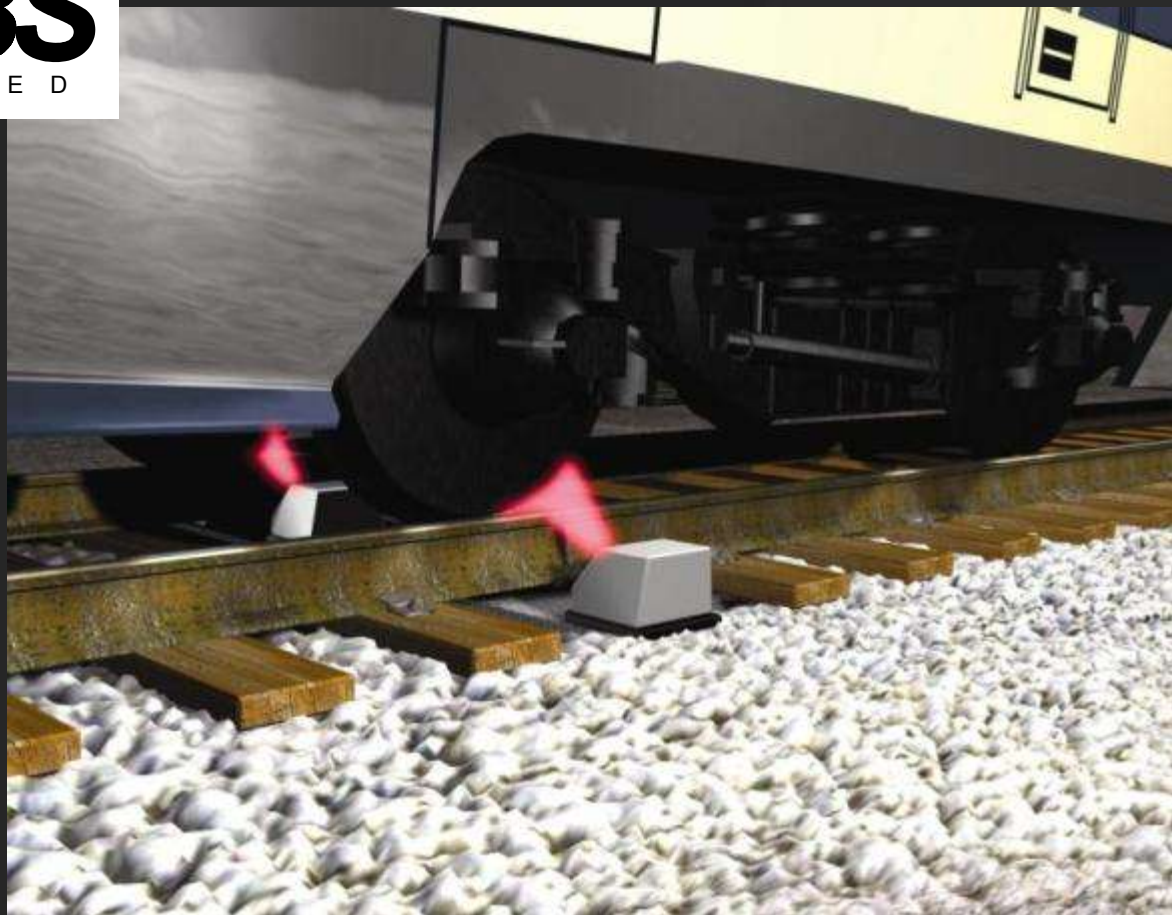
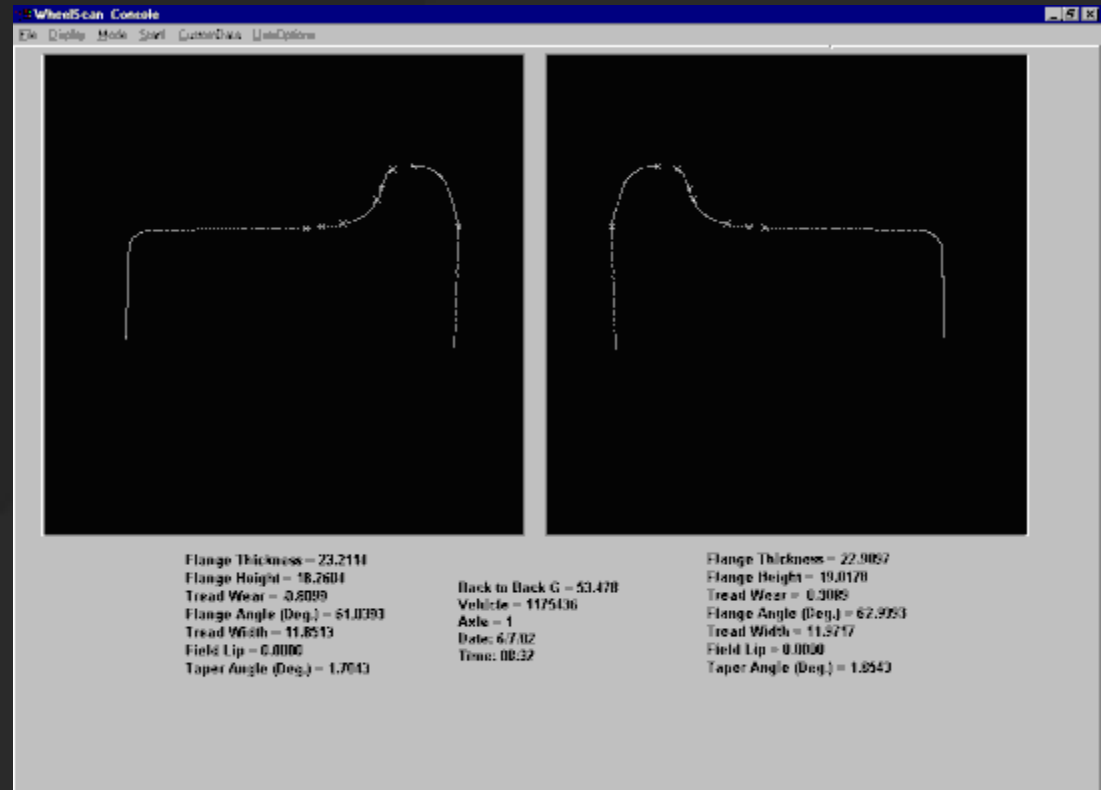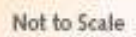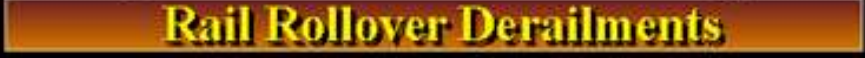# WheelScan® System for Tread Profile

Wheel Measurement Summary

- Flange Height
- Flange Width
- Flange Angle
- Tread Wear
- Taper Angle
- Tread Width
- Hollow Tread
- Back to Back Gauge
- Metal Flow (Lip)
- Diameter/Plate Type (optional)

Truck Performance Detection (TPD)

LateralKips[axle][rail][crib]

VerticalKips[axle][rail][crib]

V_I L_I V_{II} L_{II}

Rail Rollover Derailments

Instrumentatation Enclosure

Central Bungalow

AEI 0

4°- 6° Curve
(450 - 300 Meter Radius Curve)

Spiral

400' Tangent

Spiral

AEI 1

Crib1 (L/V/A)

Crib2 (L/V/A)

Crib3 (L/V/A)

Crib4 (L/V/A)

Crib5 (L/V/A)

Crib6 (L/V/A)

Instrumentatation Enclosure

4°- 6° Curve
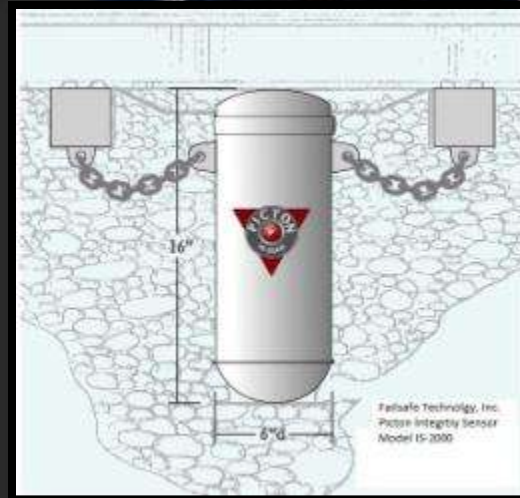r (450 - 300 Meter Radius Curve)

Not to Scale

i_E

Infrastructure Monitoring

Wayside & On-Board

Ballast Integrity Sensor™

- Infrastructure Movement Detection
- Signal System Compatible
- Remote Capabilities
- Multi-sensor Integration
- Hazmat Route Insurance
- Subterranean & Tamper Resistant

FAILSAFE TECHNOLOGY™

Asset & Tamper Protection

- Faulty Tracks
- Maintenance Problems
- Compromised Ballast
- Tracks Near Slopes
- Heavy Rainfall
- Earthquakes

FAILSAFE TECHNOLOGY™

Aurora® Tie Inspection System

-Full scale wood tie grading supporting system tie estimating, planning, marking, and tie unloading

-Concrete tie assessment (rail seat deterioration, fastener and insulator orientation)

-Working with existing customers on development of automated tie marking vehicle based on Aurora data
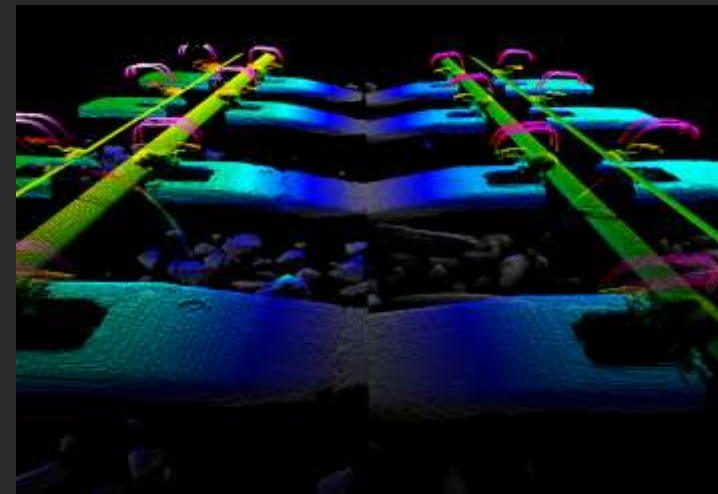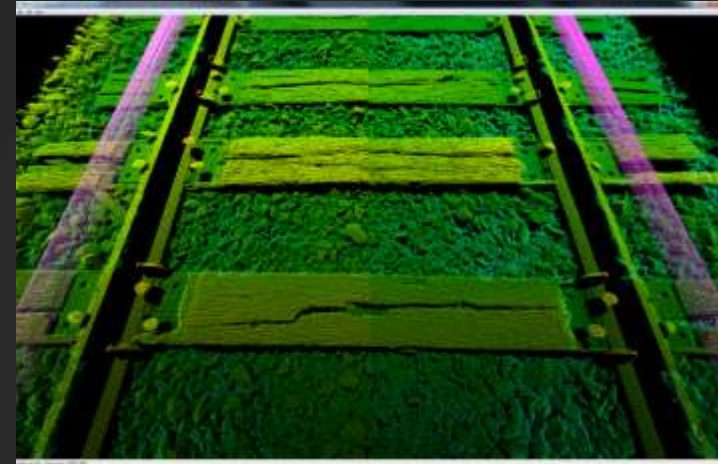
GREX Inspection Technologies

GPS Based Mapping of Collected Aurora Miles
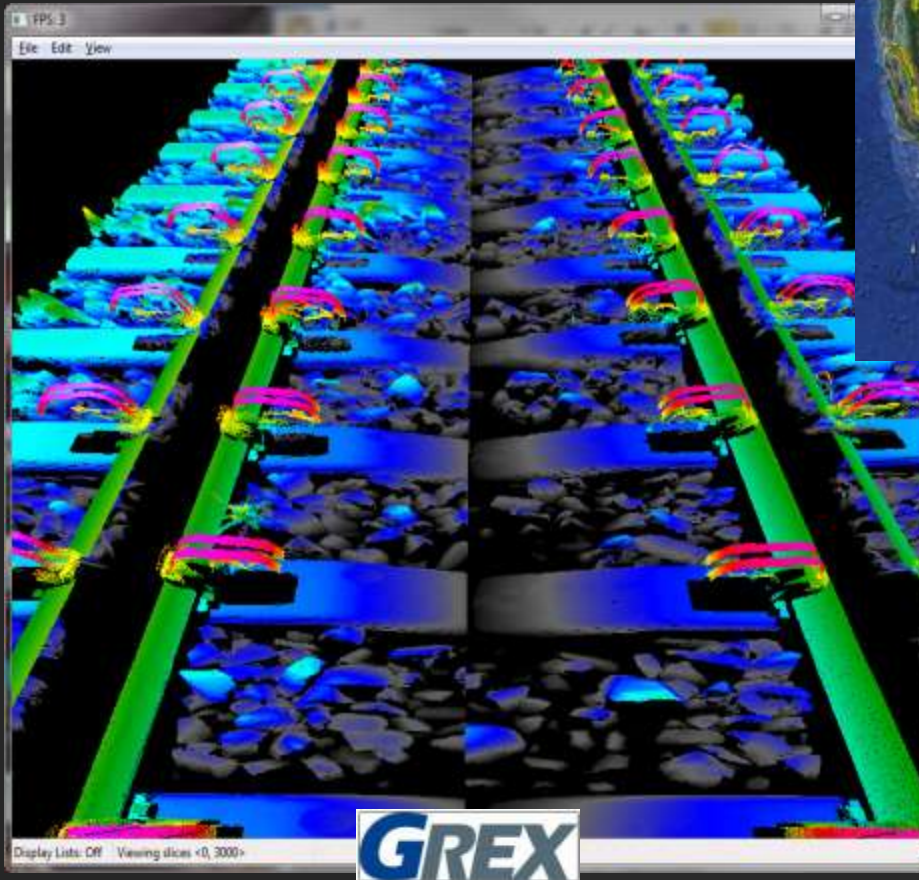
-Aurora fleet consists of seven trucks with historical productivity of approximately 1,000 miles per month per truck

-Working with existing customers on development of automated tie marking vehicle based on Aurora data

BallastSaver™

-BallastSaver™ is a LIDAR based track inspection system designed to scan the track at 20 mph and calculate ballast deficiencies over many mainline track miles

-Ballast surveys are used to automate the ballast delivery process by integrating with GREX's GateSync™ software on ballast trains
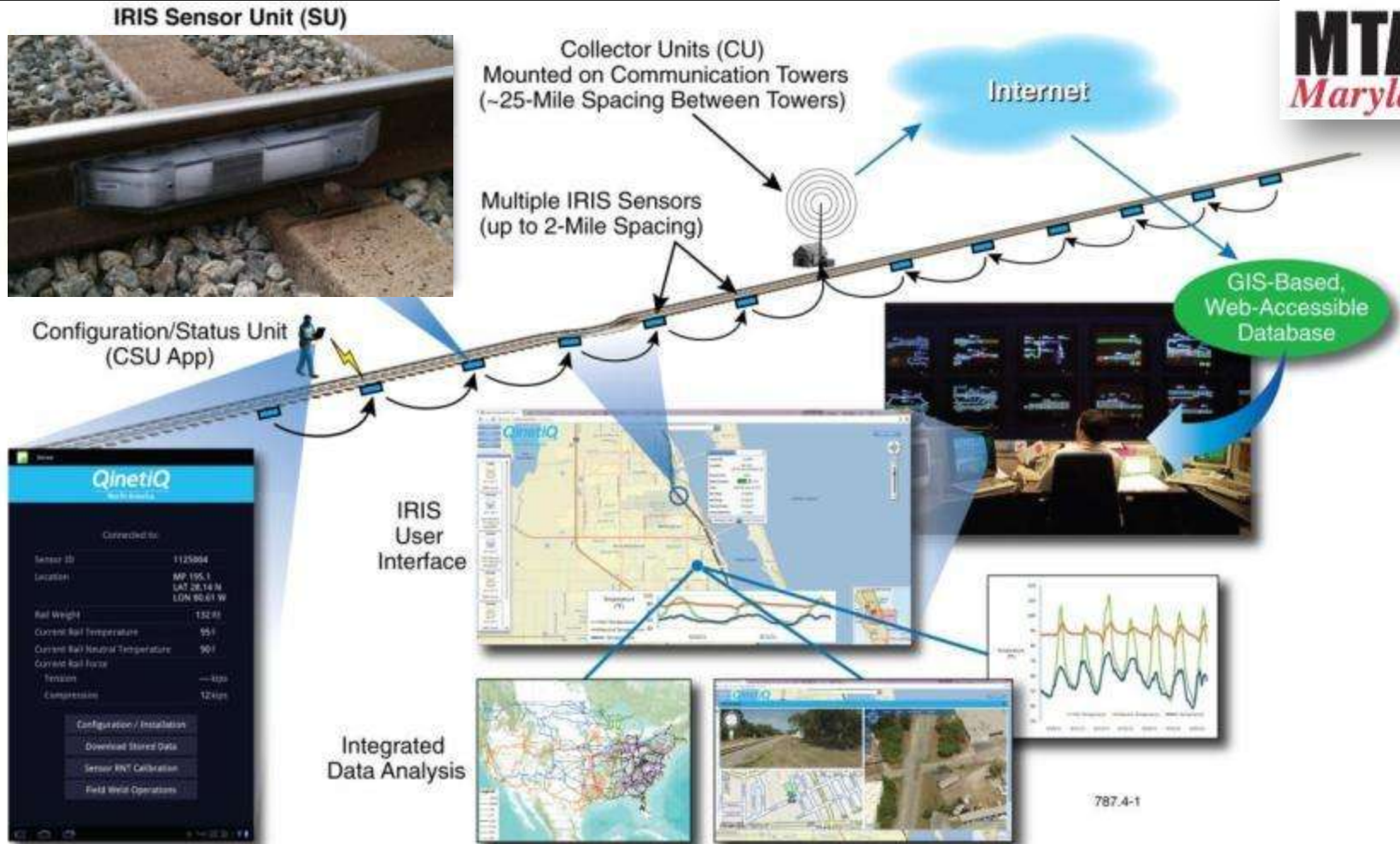
BallastSaver™

-Extensively tested to evaluate accuracy & precision of volume calculations

-Areas colored in red indicate deficient ballast at the end of ties as well as crib ballast deficiencies

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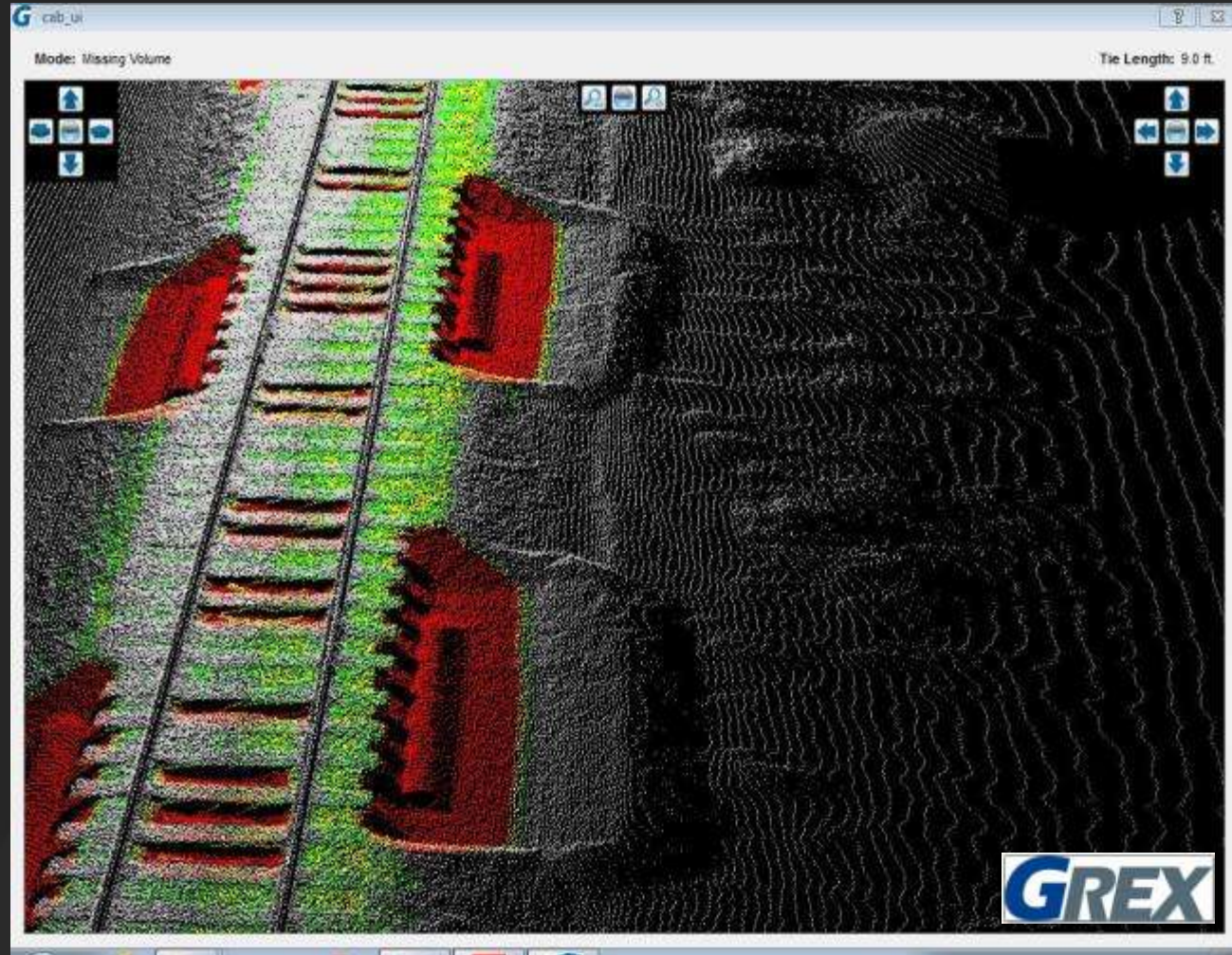
Rail Stress Monitoring System

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ProTran Technology

Sensor Unit (SU)

- Continuous data collection of Rail Stress Condition

- RF data transmission to web and CSU

- On-board processor calculates RNT and monitors for track failure

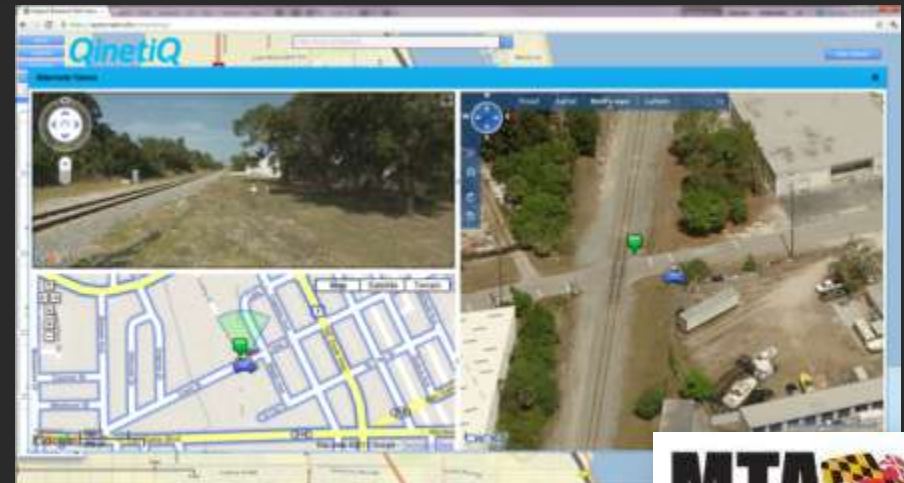- Up to 13 SUs per Tower (CU) can be daisy chained to cover 25 miles of dark track in each direction
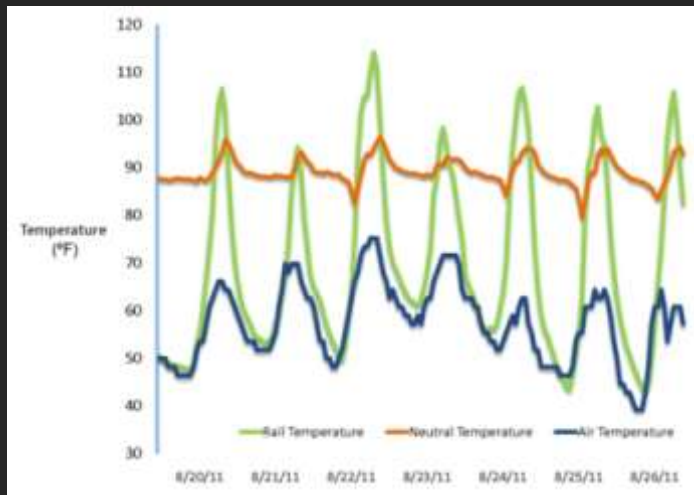

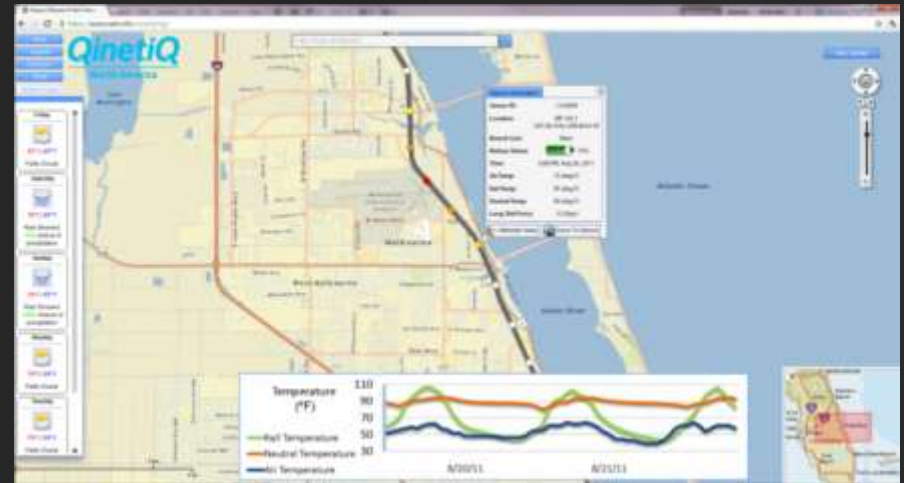**MTA Maryland**

ProTran Technology

Web-Based User Interface (WUI)

- ♦ Secure log-in
- ♦ Graphical display of data and sensor location (MP and Lat/Lon)
- ♦ GIS Overlay (Road maps, grade-crossings, etc.)
- ♦ RNT monitoring
- ♦ Current and forecasted weather
- ♦ Color coded risk mapping (planned)

ProTran Technology

Installation Examples

ProTran Technology

MTA Maryland
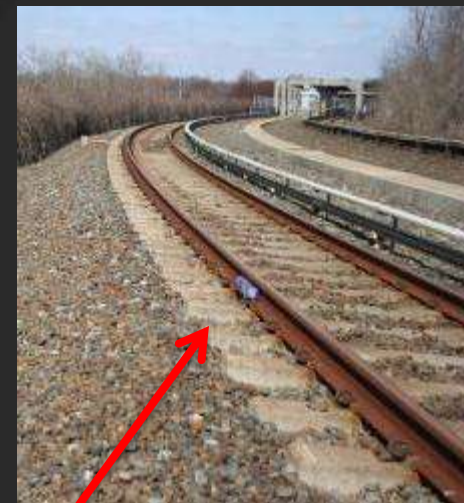
Street View with Measurement Locations

Menu

Legend

SUs

Maps Selection
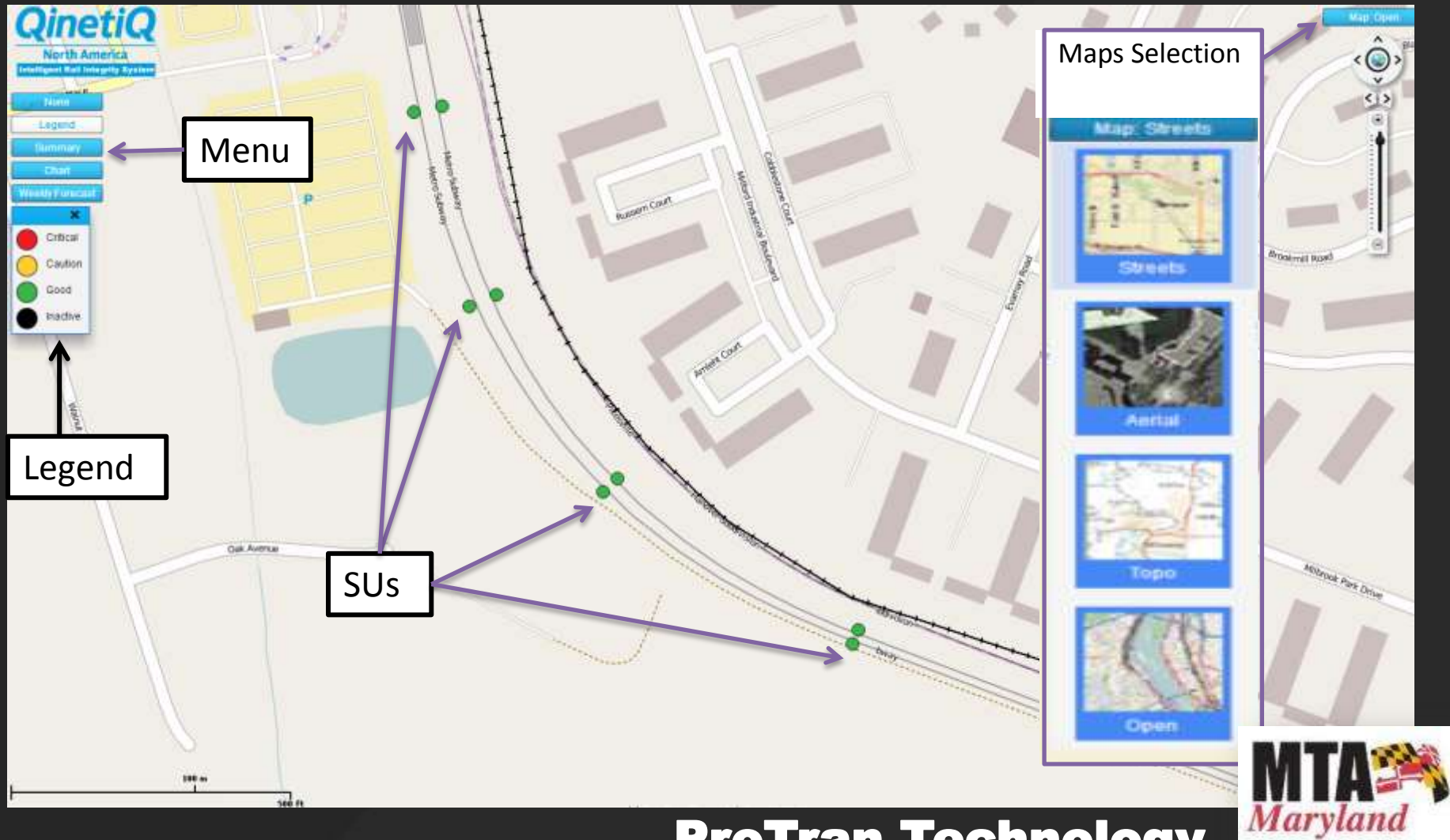
ProTran Technology

Track Recording Vehicle

ORIAN Sensor Heads

ORIAN Computer System (OCS)
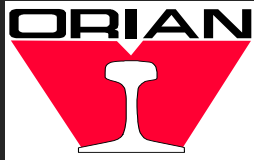
Rail Measurement Summary

- Rail height
- Vertical wear
- Rail width
- Lateral wear
- Gauge Face Angle
- Gauge lip
- Field lip
- Rail inclination
- Gauge
- Rail Identification
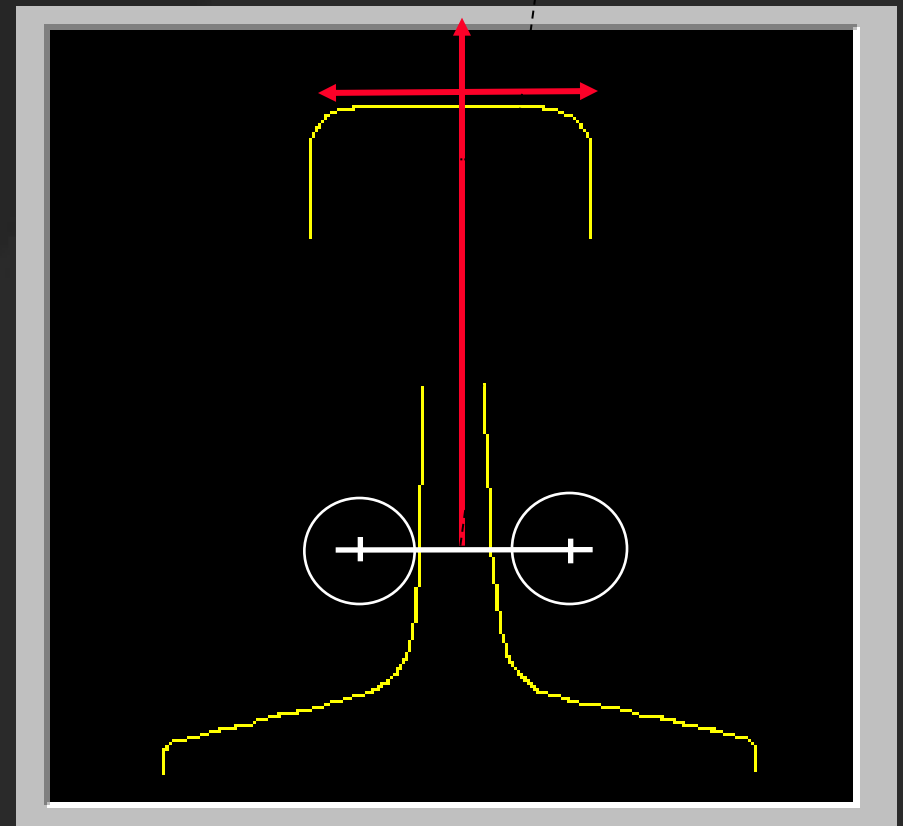
Tribometer
(Friction Management)

Rail Defect Inspection Technologies

Ultrasonics

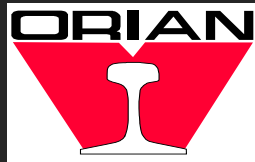Magnetic Flux leakage

Pulsed Eddy Current

Alternating Current Field Measurement (ACFM)

Electromagnetic Acoustic Transducers (EMAT)

Visual Camera Systems

Laser Ultrasonics

Ultrasonic Phased Arrays

Long Range Ultrasonics (Guided Waves)

Multi-Frequency Eddy Current Sensors

Magnetic Anisotropy and Permeability Systems (MAPS)

RCF Cracks on High and Low Rails

Rail Cracks Develop into Spalls

Cracks, Plastic Flow and Spalls

Low Rail Before Grinding

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Low Rail After Pass 1

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T E C H N O L O G Y   &   G L O B A L   C O N N E C T I O N S

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Low Rail After Pass 5

Even after 5 passes, cracks are still visible!

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Measuring Rail Head Cracks

- Eddy Current Instrument - "Rohmann Draisine"

- Walk-behind System Shown

- Knowing depth of cracks both pre & post grind improves grinding program effectiveness

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Pre-grind Crack Measurements

- Pre-grind crack measurements were taken from the low side of the Wabun curve

- Vertical scale: 0 – 5 mm; different mm are color-coded

- Horizontal scale: 100 m (each bar represents the worst cracks found in 1 m)

- Cracks were measured between 1 and 3 mm on ground track, and over 5 mm on the two bridges (which had been skipped by the grinder in recent years)

Post-grind Crack Measurements

- After 5 grinding passes, which did include the two bridges, crack measurements show reduced to less than 1 mm on ground track and less than 3 mm on the bridges

- Vertical scale: 0 – 5 mm
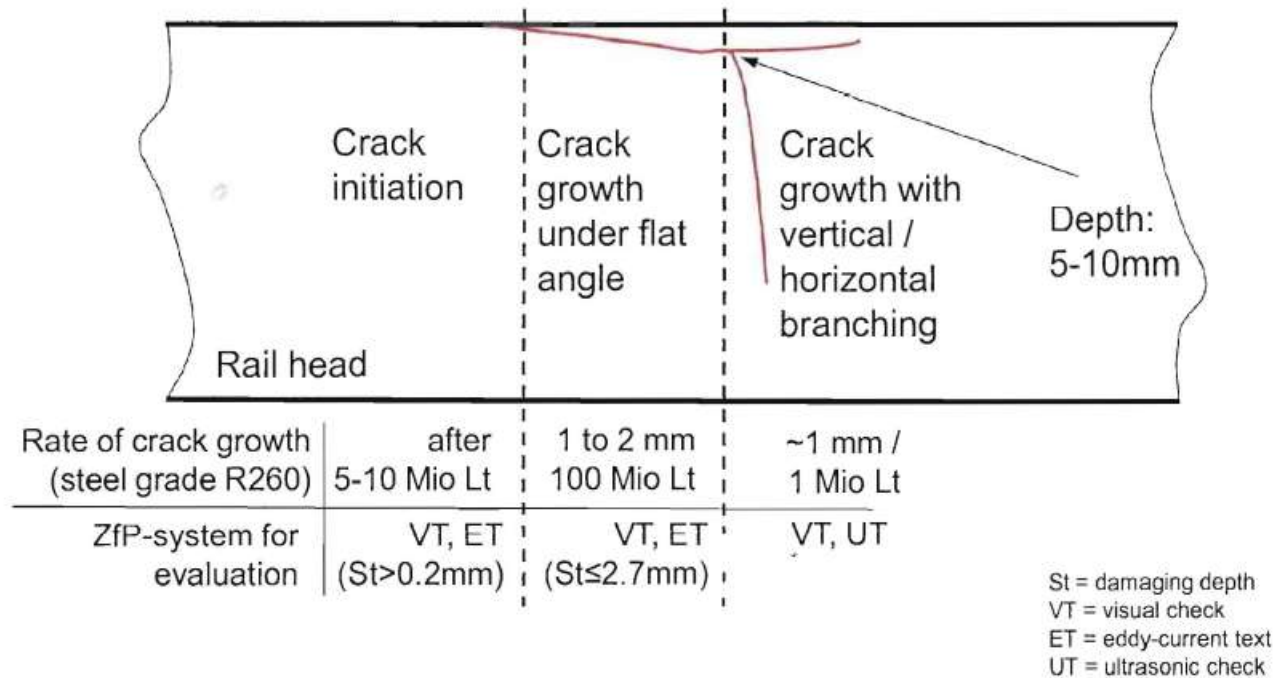
- Horizontal scale: 100 m

Deutsche Bahn Crack Growth Model

Crack growth divides into three stages

DB NETZE

Head Checks – Path of crack and speed of crack growth

Crack initiation | Crack growth under flat angle | Crack growth with vertical / horizontal branching

Depth: 5-10mm

Rail head

	Crack initiation	Crack growth under flat angle	Crack growth with vertical / horizontal branching
Rate of crack growth (steel grade R260)	after 5-10 Mio Lt	1 to 2 mm / 100 Mio Lt	~1 mm / 1 Mio Lt
ZfP-system for evaluation	VT, ET (St>0.2mm)	VT, ET (St≤2.7mm)	VT, UT

St = damaging depth
VT = visual check
ET = eddy-current text
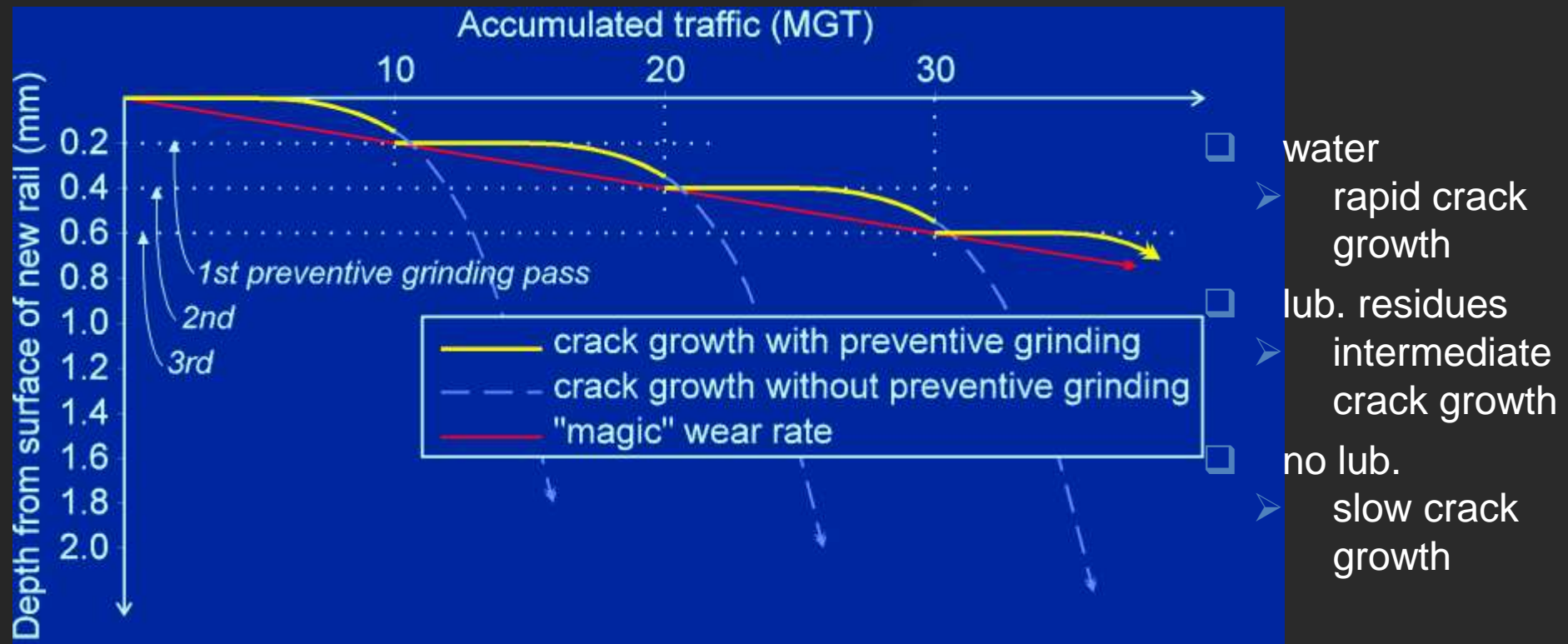UT = ultrasonic check

DB Netz AG, 30.03.2010

6

Source: project IOS, TP 1, Dr. René Heyder, VTZ 35, 08.04.2008

Rail grinding

Preventive grinding (frequent light cuts) is more economical
than corrective grinding (infrequent multipass deep cuts)

**Contact fatigue crack growth in rail located in a sharp curve (>3°) as a
function of accumulated traffic with and without preventive grinding**

Sub-Surface Portable Ultrasonic Rail Flaw Detection System (HANDWave)

Experience driven design for effective Rail Testing

Reduces costs by requiring less testing time (track occupation)

Main line testing and spot checking mode in one unit

Powerful ultrasonic and post-test analysis software

HANDWave 3 way, versatile setup; Single, Dual and Dual towed

C.A.T.E.R

Who's Using?

Wayside & On-Board

Transit Properties

New York City Transit

Plasser & Theurer
KLD LABS — MEASUREMENT TECHNOLOGIES
Nordco

- Track Speed Inspections
- Track geometry
- Rail Profile and Rail Wear
- Third Rail
- Flangeway
- Tunnel measurements
- Video Inspection
- Ultrasonic

KLD LABS — MEASUREMENT TECHNOLOGIES

METROLINX

- Brake Inspection
- Wheel Profile
- Wheel Wear
- Back to Back Gauge

Freight Properties

- Speeds of up to 70 mph.
- Inspections 6 days a week.
- 11 onboard computer
- Track geometry
- Rail Profile and Rail Wear
- Tunnel measurements

- Brakes
- Springs
- Wedge Rise
- Coupler
- Wheel Profile/Wear/B to B Gauge

Do we want DATA or INFORMATION?

Tools for to turn "Data" into "Information"
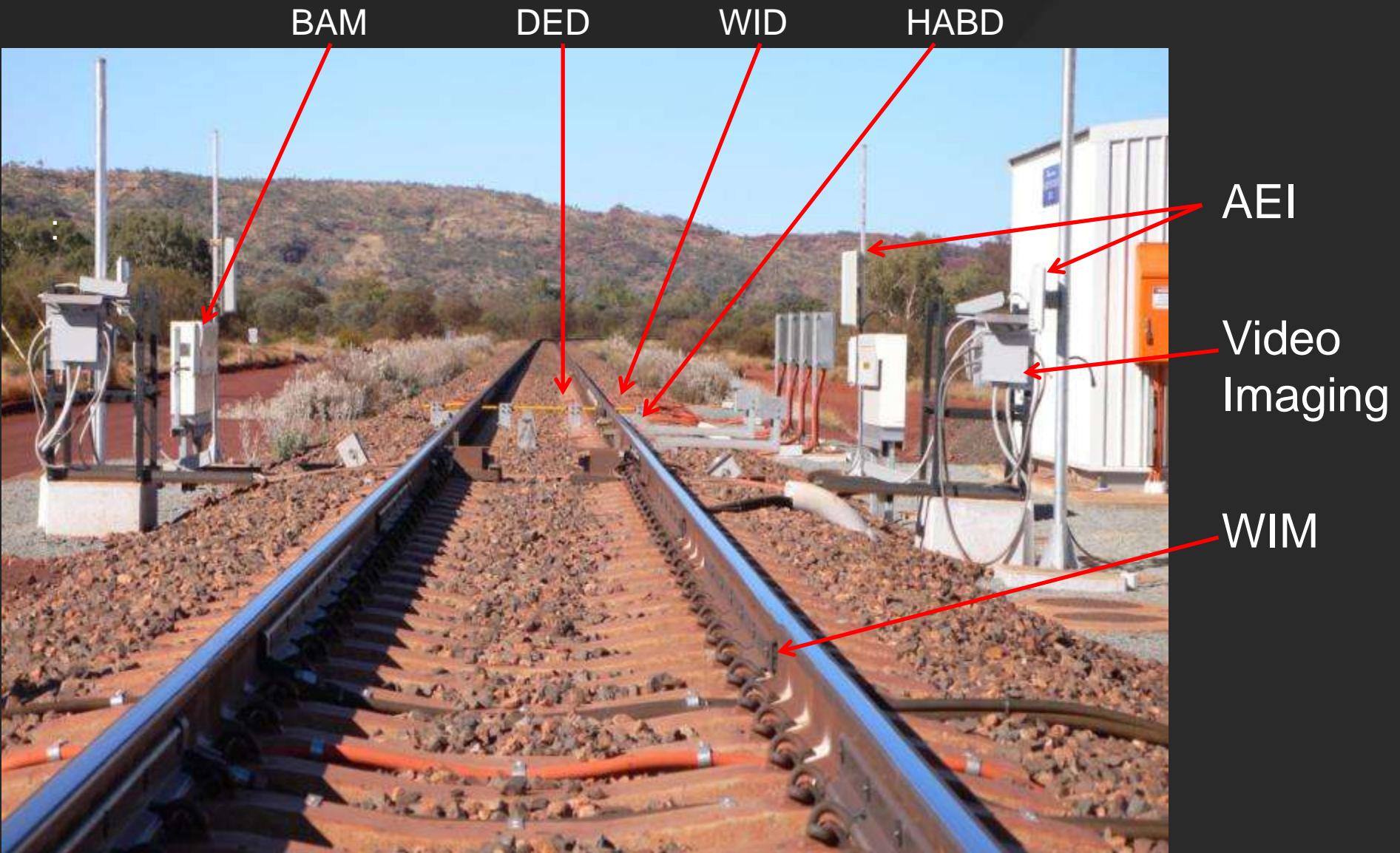
•Weather Stations

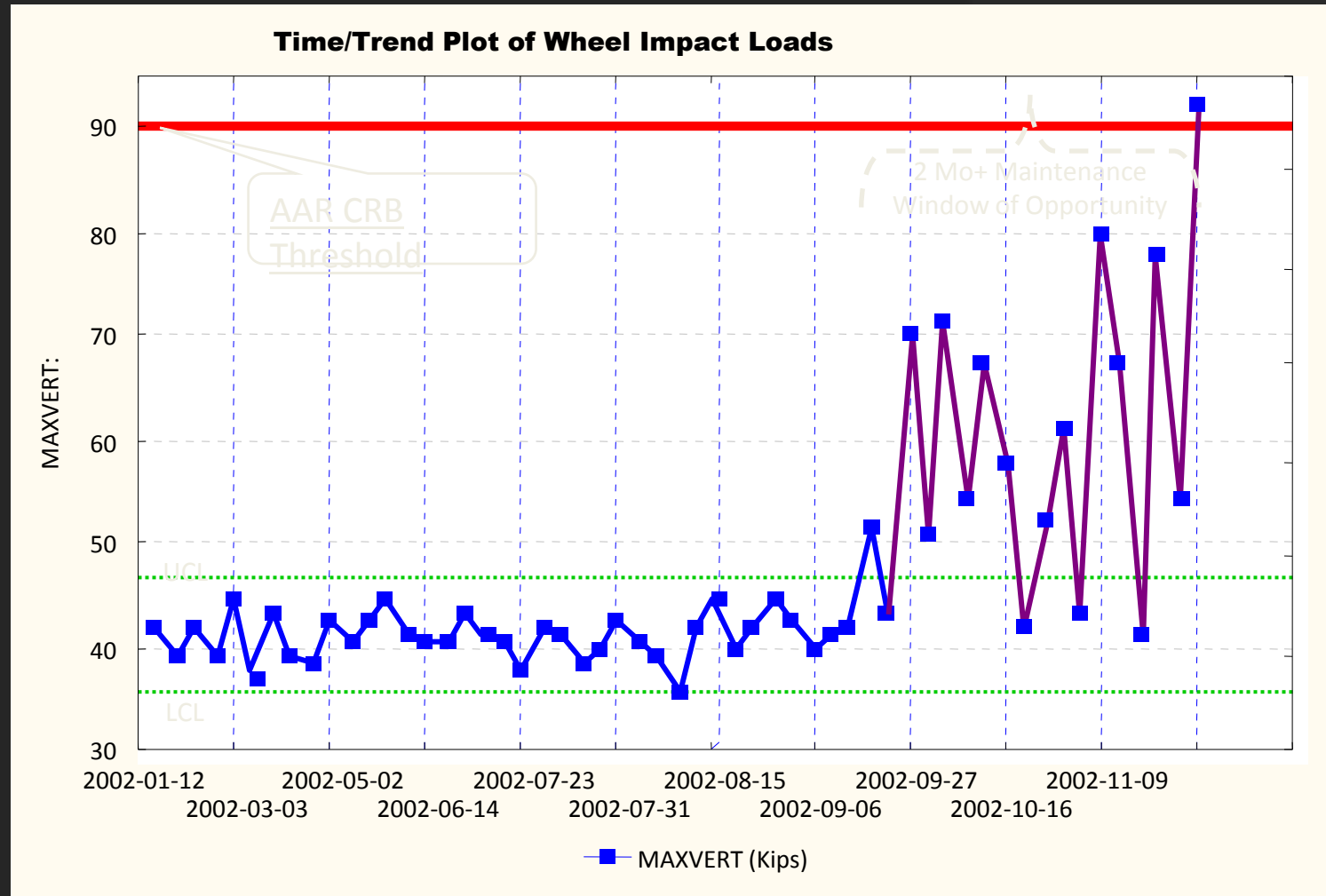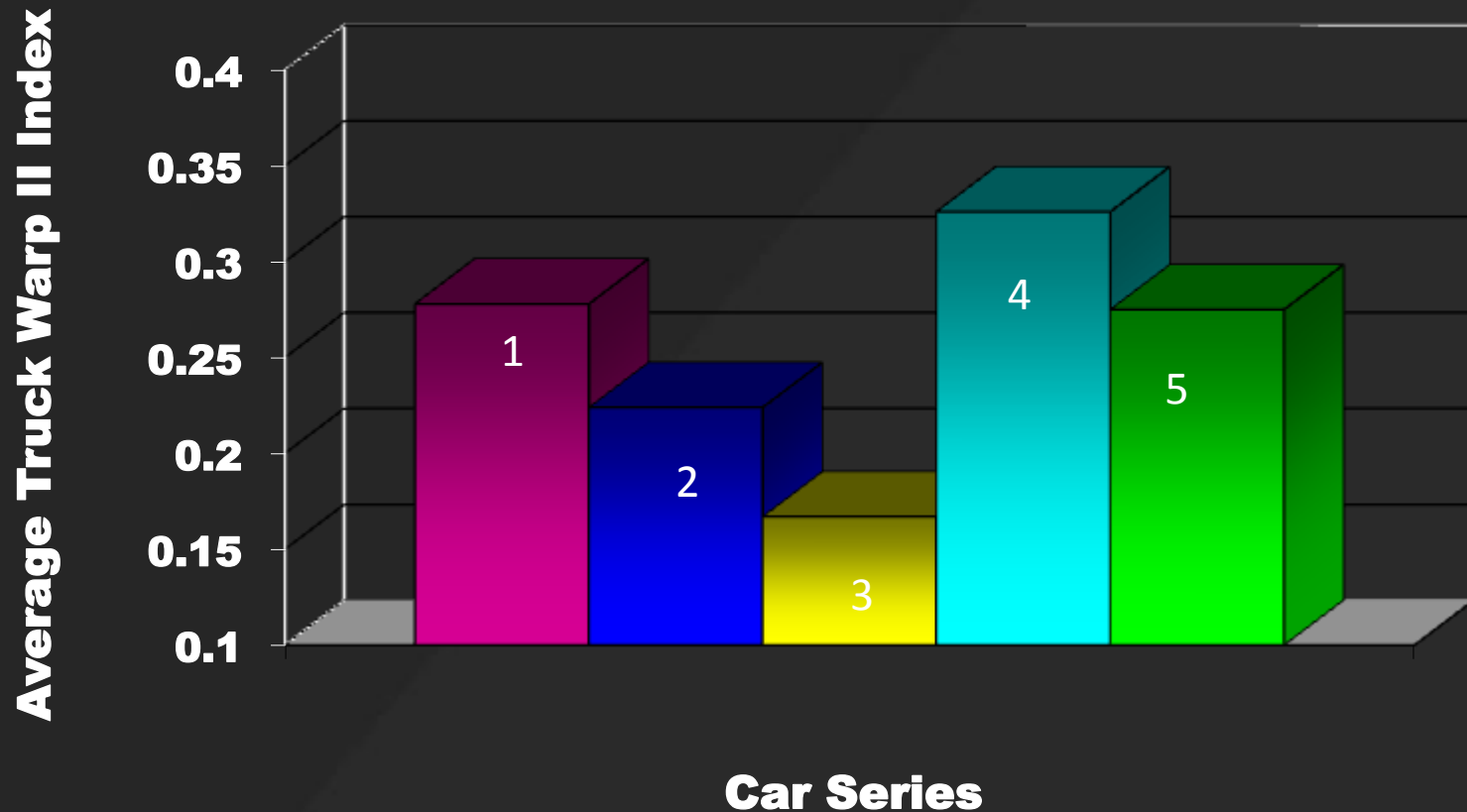•Vehicle Identification

Communications are a Key Issue to Address

Integrated Sites

BAM   DED   WID   HABD

AEI

Video Imaging

WIM

Individual Vehicle Performance

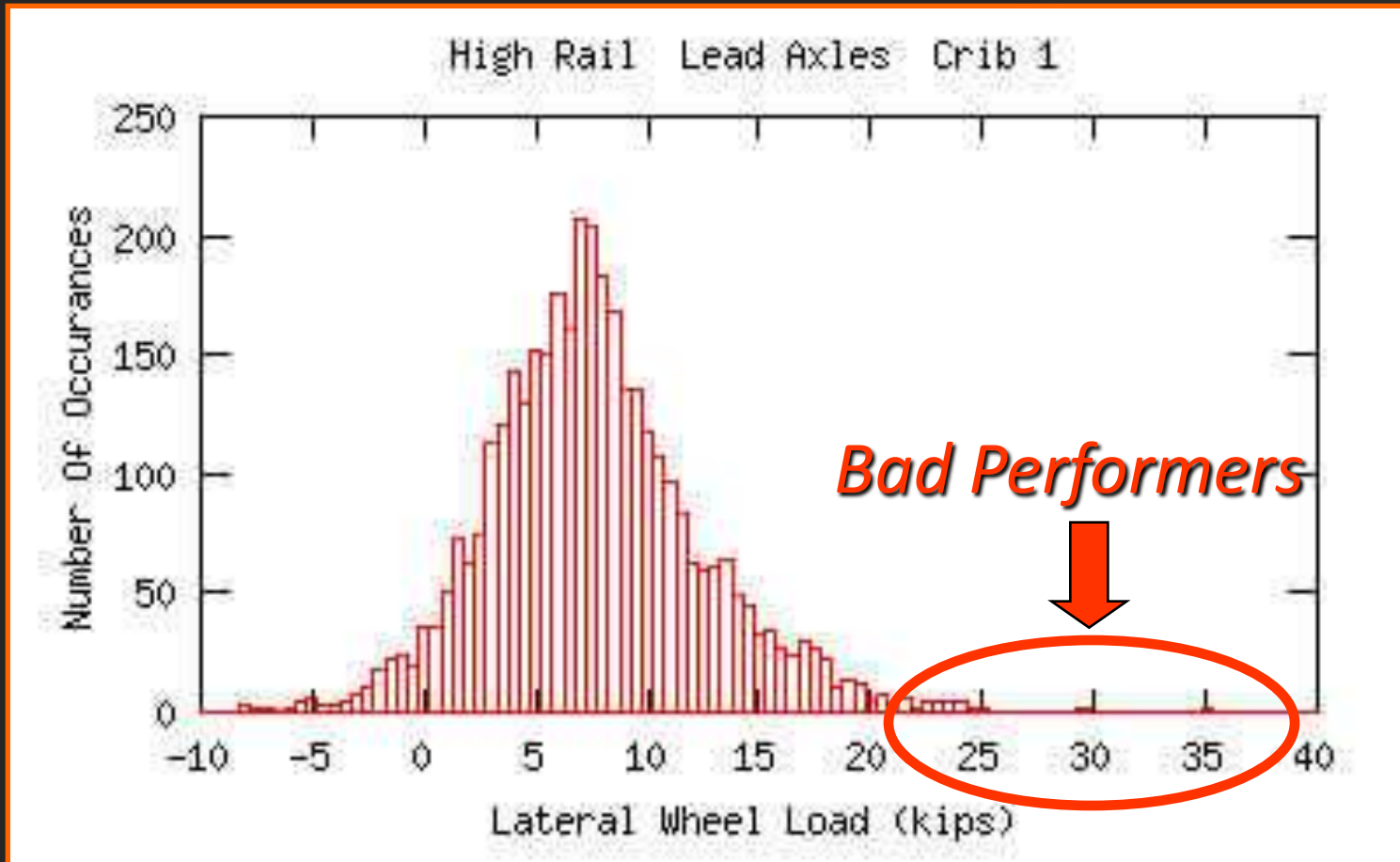Time/Trend Plot of Wheel Impact Loads

Specific Series Performance

Overall Fleet Performance
(Lateral Loads in 6-deg Curve)

Bad Performers

What does your fleet look like?

Thank You

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