Automated Vehicle and Track Inspection Systems

Technology and Analysis

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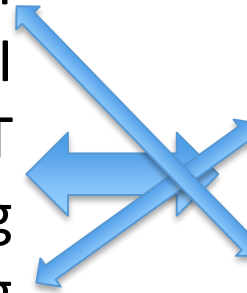
Automation

HBD trending, AEI
WILD, TPD, VTI
Shop/Train/Track UT
ABD, WPD, Bar Coding
Track Geometry, Imaging
MTOR, Train Imaging

Signal/CAD
Train Control
Track Network
Umler, CRB, MOW

"1994 Quenchometer"

Zzzz...

– System Installation/Maintenance
  • Auto-config / health monitored
– Data Capture, Processing, Analysis

Clean, Aligned Datasets

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Introduction

Silver Bullet Innovations

1. Precision control of wheel/rail interaction
2. Computer-assisted rolling stock inspection
3. Computer-assisted track inspections
4. Communications-based train control
5. Autonomous train operations

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Innovation Capabilities?

- Tech as a Commodity
  - Software/Platform as a Service (SaaS/PaaS) replacing centralized systems
- Inevitable IoT/Autonomy
  - Sensors on every switch, joint, bridge, car
  - Systems moving to locos/cars/drones
- Continuous/Performance Testing
  - Rail UT, Air Brakes (Wheel Temp Detector)
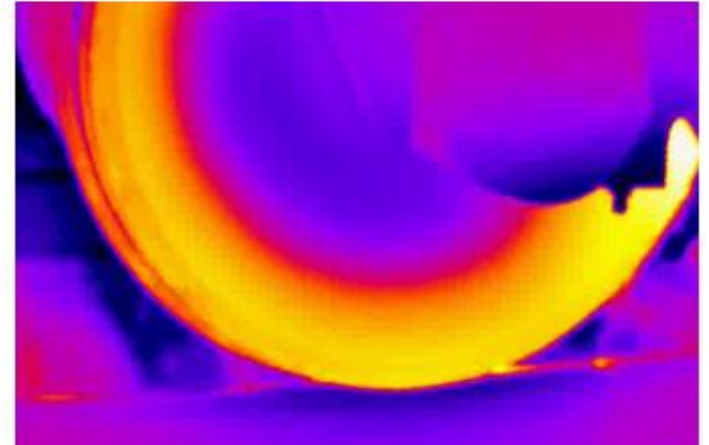
Less Reactive -> Proactive?

State of the Art Systems

- *More low level d*ata to exploit (scalable)
  - System health/heartbeat
- Edge Computing (In-Situ, near real-time)
  - Self or Cross Calibration
  - *Designed for integration*
- Utilize SaaS/PaaS
  - *Artificial Intelligence / Machine Learning*
  - 1 - Universal Identification (Location)
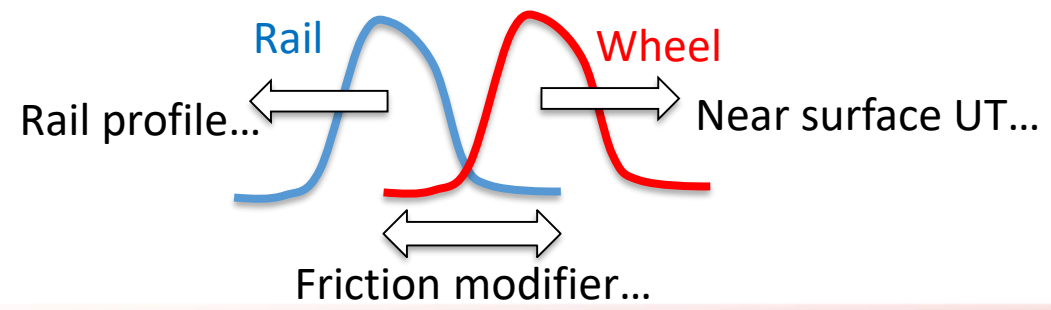 - 2 - Error Elimination

Clean, Aligned Datasets

Wheel Life Extension

Rail profile... ⟵ Rail   Wheel ⟶ Near surface UT...

⟷ Friction modifier...
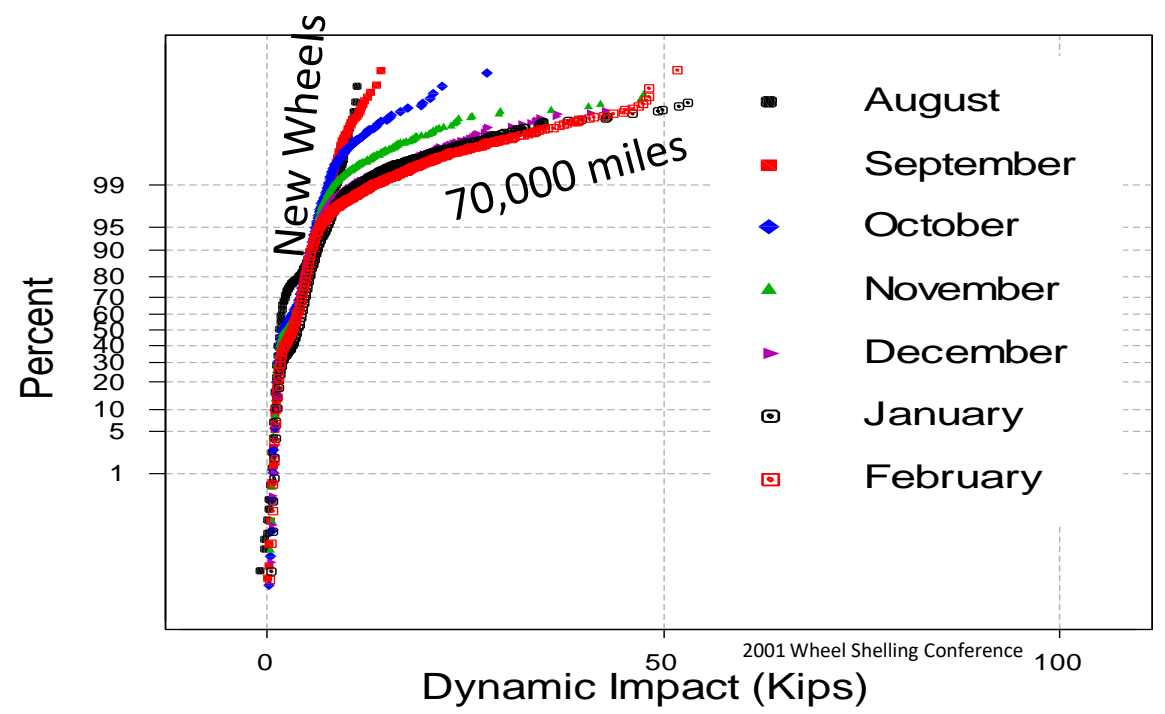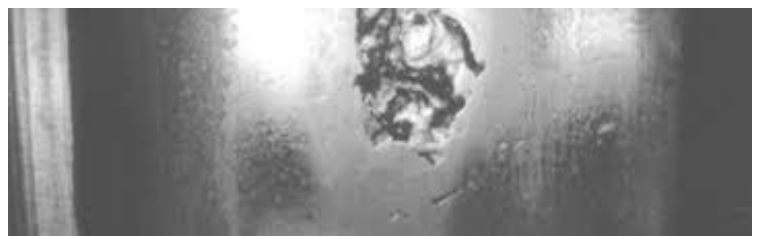
- Some RCF History
  - Based on Service (sliding)
  - Based on Shoes (wear (MWR))
  - **Based on Position (steering)**
  - Based on Braking (heat(prelim))
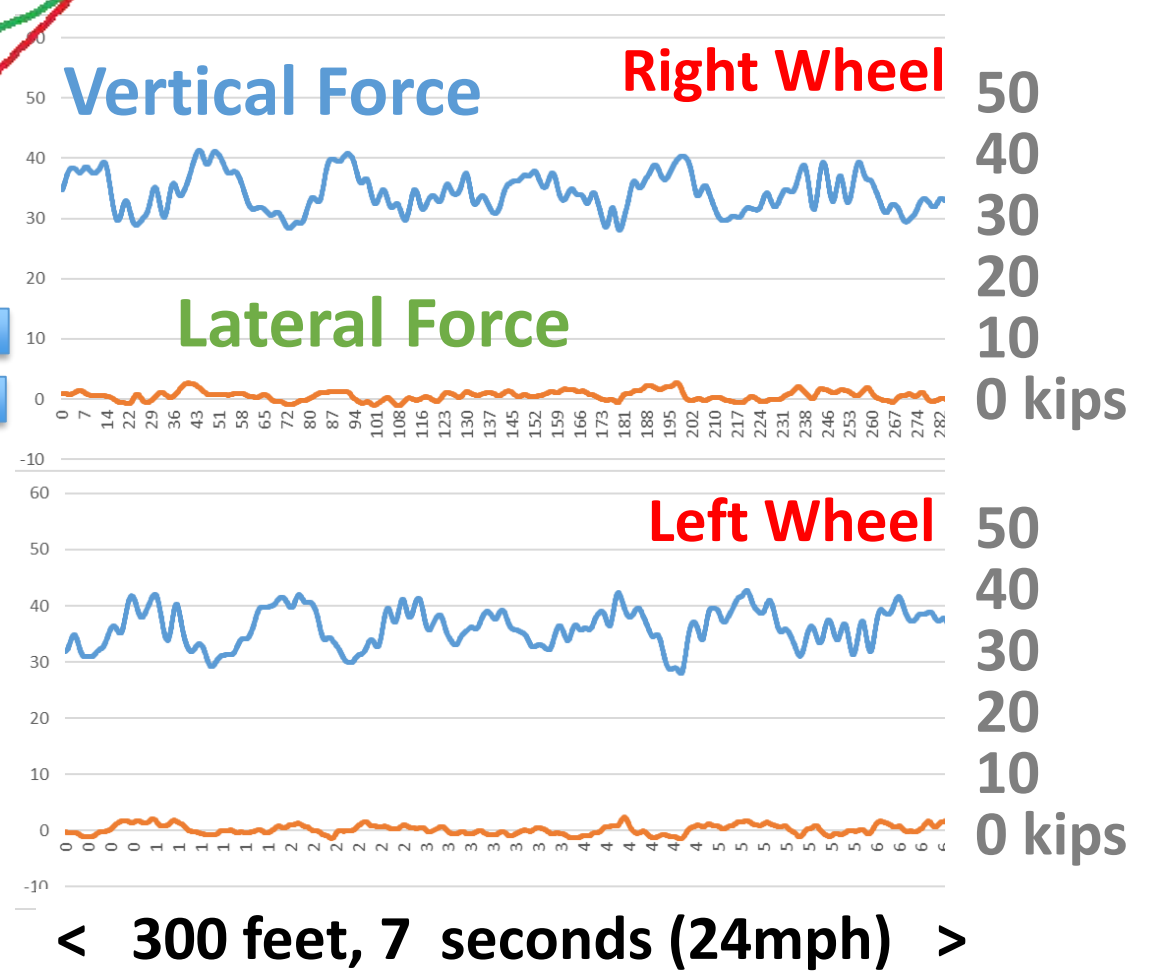
Measure/Control Steering Forces

Instrumented Wheelset (IWS)

- Take/Send data

- Vertical/lateral force
  – Set Lateral Thresholds/Alarm

Reactive for track
Preventive for wheels

Curve->

Tangent ->

Vertical Force **Right Wheel**

50 | 40 | 30 | 20 | 10 | 0 kips

Lateral Force

Left Wheel

60 | 50 | 40 | 30 | 20 | 10 | 0 kips

50 | 40 | 30 | 20 | 10 | 0 kips

<   300 feet, 7 seconds (24mph)   >

IWS Trending

- 'Bad' Performance (trending, comparisons)
  - Requires automated "Overlay"
  - ... integration with many other data sources
- Process Efficiencies (find/fix) + IMAGING?
  - Bad spikes, switch, crossover
  - Bad geometry, mudhole, ballast, subgade
  - Bridge issues
- Extending Rail/Wheel Life (prevent)
  - Balance speed, Friction modifier
  - Truck selection / maintenance processes
  - New products/designs (rail or rolling stock)

Integration with… ?
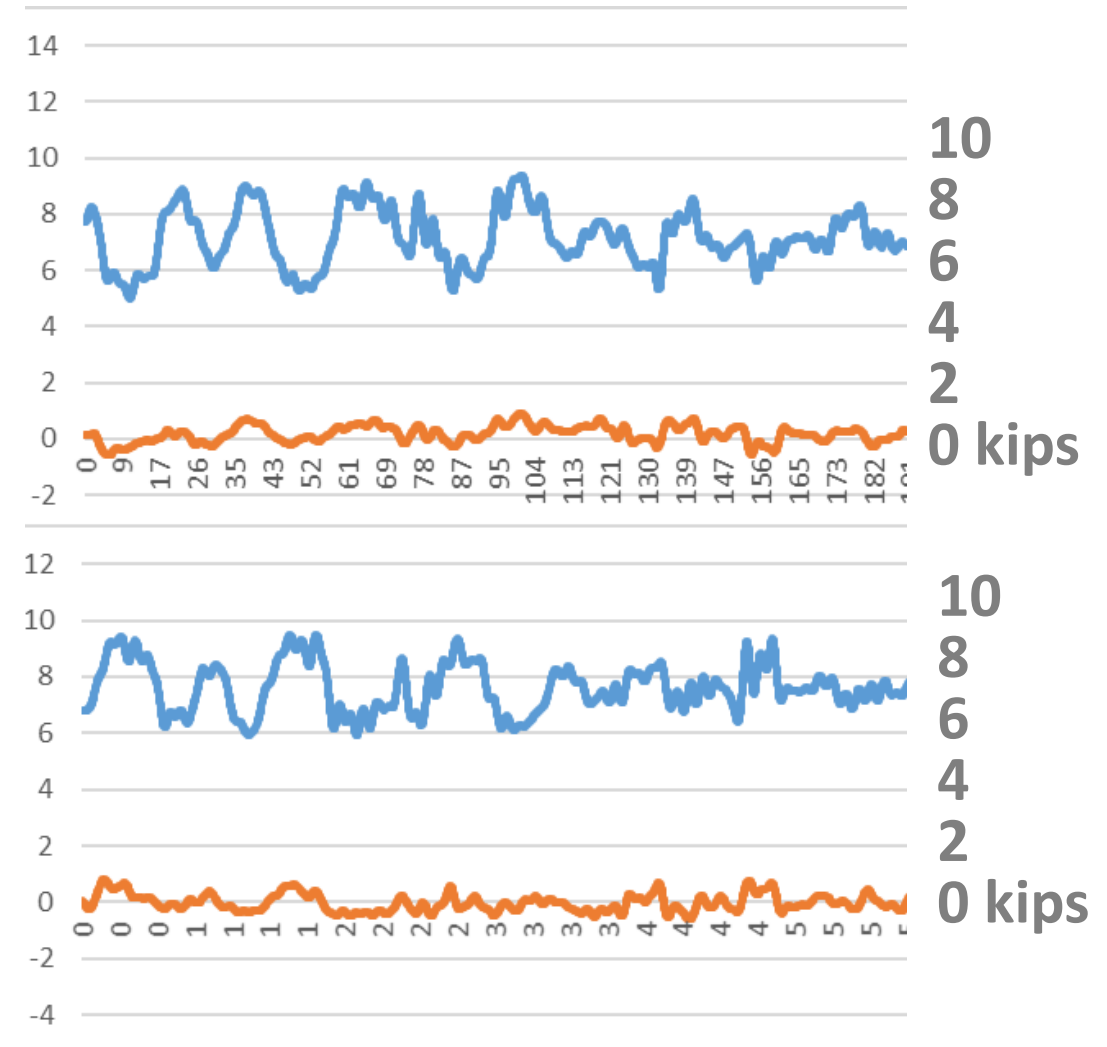
Universal Identification Model
-Track/Fixed Assets-

Most Challenging Track Features

Ties, bolt-hole, spike
Side (Which Rail)
Wheel Sensor, Tower

Unique ID Yields Best Prioritization, Trending
Yes, the UT indication is at a weld #432

Dynamic Time Warping [Distance (GPS, encoder) ➡ Previous Shape(s)] x Splined Anchor points

Curve/tangent

Joint
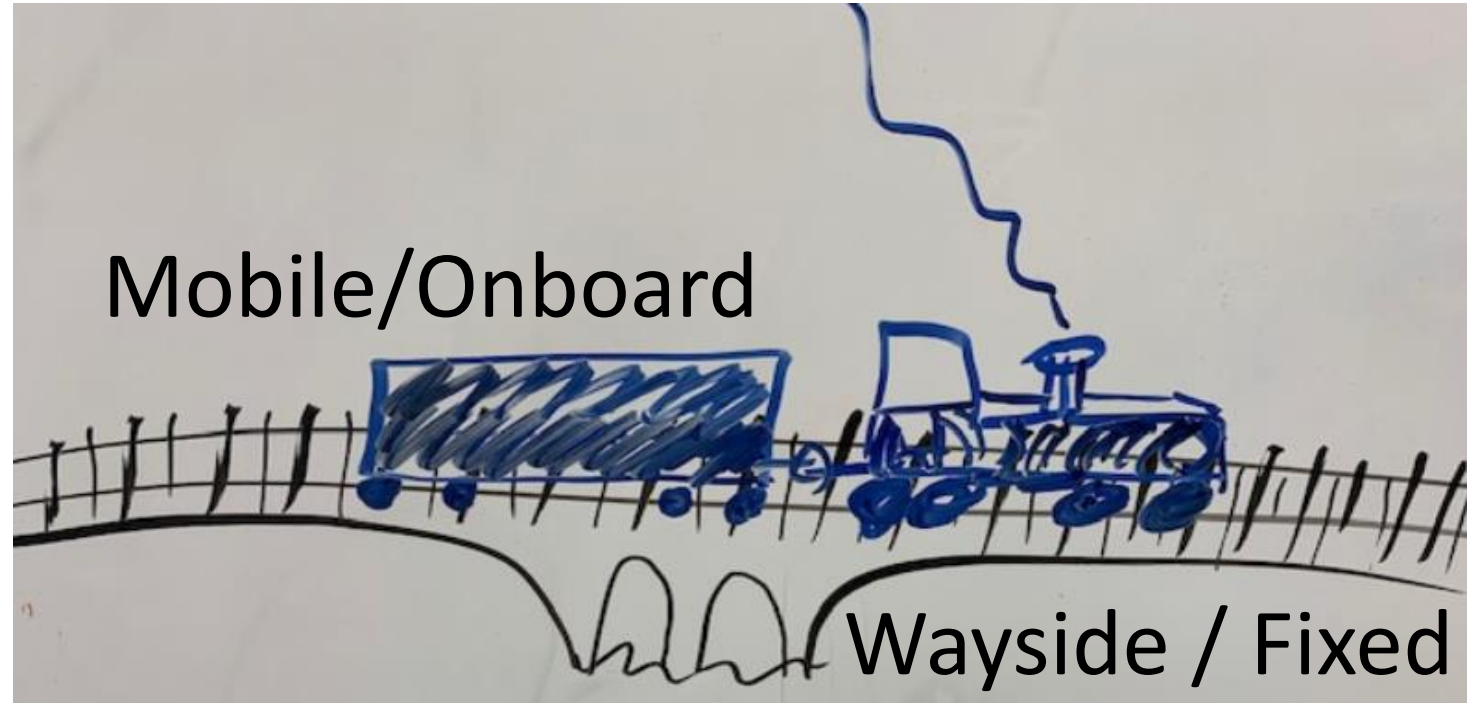
Switchpoint

Bridge Pier 5

Pole   Bungalow
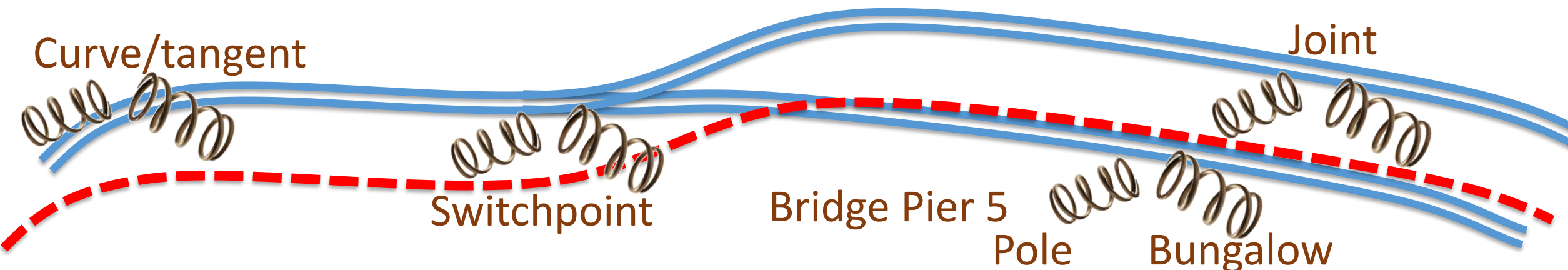
Wheel/Rail Interaction Ecosystem

- Examples
  - Bridge Monitor
  - Ground Penetrating Radar
  - Gage Measurement
  - Instrumented Wheelset
  - Vehicle/Track Interaction
  - Wheel Impact/Load
  - Wheel Profile
  - OnBoard/Motes

Mobile/Onboard

Wayside / Fixed

**Methods – Fixed and Mobile
Either can inspect the trains or the track**

Universal Identification Model
-Train/Rolling Stock/Mobile-

Most Challenging Vehicle Features

Side (Orientation)
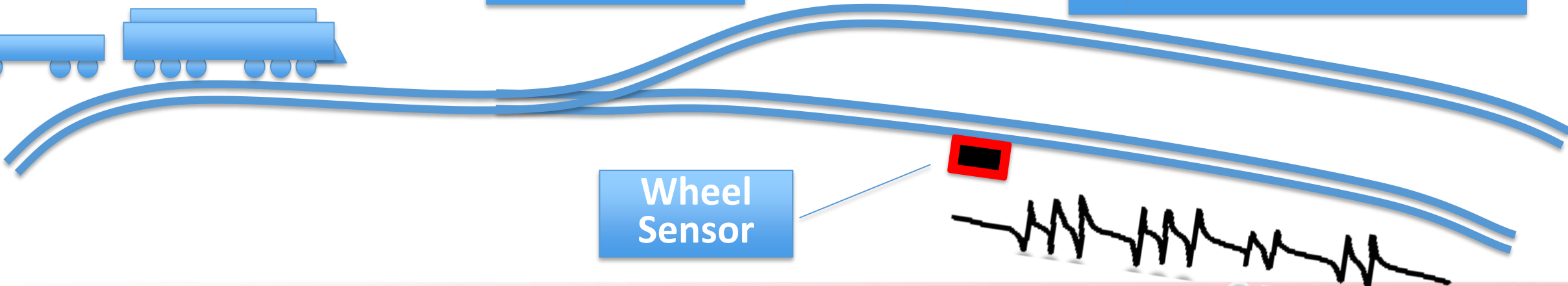Valves, gates, brake rods
MV + OnBoard
Wheel Sensor Timings

AEI/S# required for trending

Consist is Base/PK

Truck Patterns → Vehicle Patterns

All Attributes
AEI or OnBoard S#
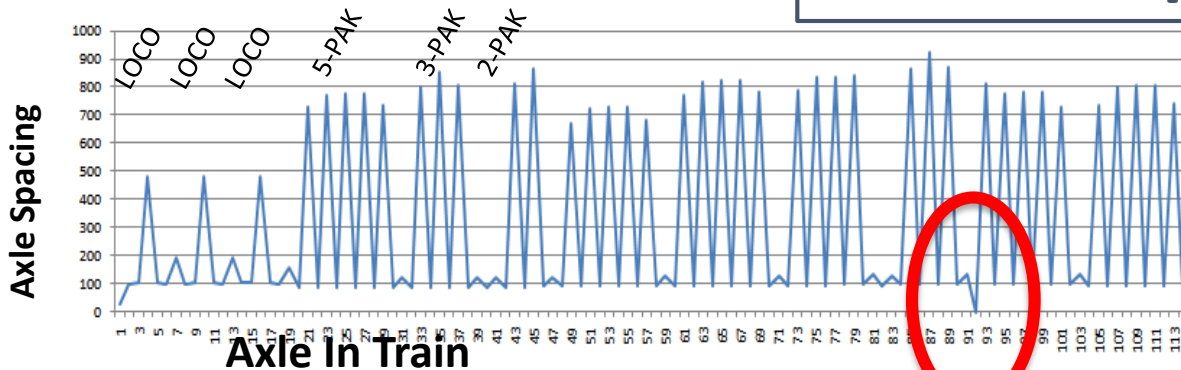
Wheel Sensor

(#2) Error Handling Options

99% Correct, 1% error

- Best Guess Method
  - AEI Cross-read or Orientation or Train ID
  - Wrong Track or Rail# or Subdivision

100% correct, but 20% dropped

- No Guessing Method
  - Error proofing
  - Running the Gauntlet
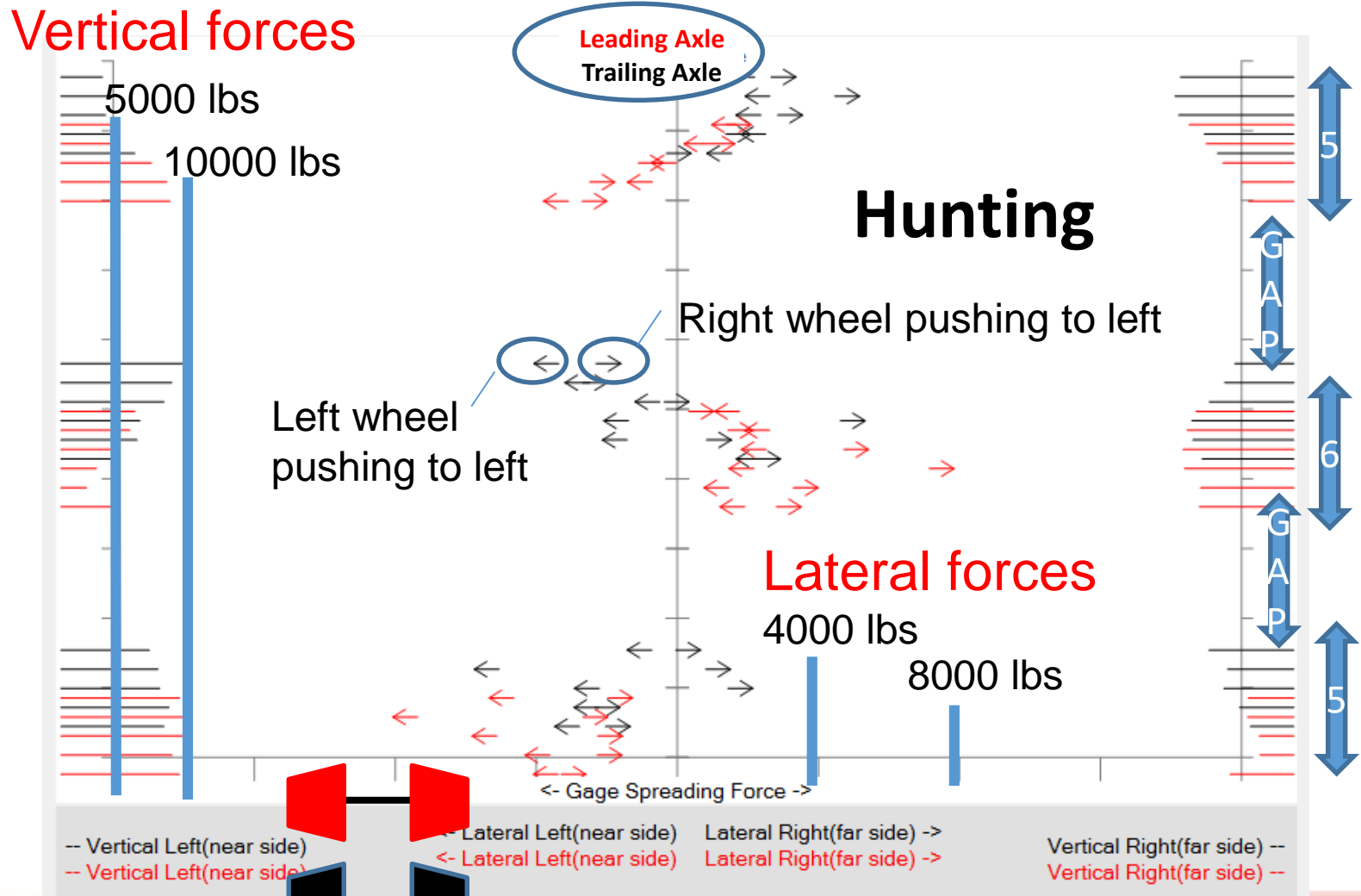
Which Option Should I use?

Choose Error Proofing

- Wayside
  - 20,000 cars per day
    - 200 errors (1% rate)
      - 73,000 per year
        » 1% actionable/billable
        = 730 stops/looks/wheelsets
  - Loco orientation / Wheel Wear Rate
    - Weekly Repeat Traffic
      - (99% good)^52 = 59.3% good

- Track
  - 5 mile data set
    - 20/day – 7300/year
      - 73 wrong data sets
        » 36.5 trending alerts for wear > 0.1"
        » 2 real trend alerts

- *Machine Learning*
  ~ 10000 sets w/100 defects
  …You will never get there

Trending Math is very different from Reactive logic

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WRI 2019

Example: WILD

Vertical forces

5000 lbs

10000 lbs

Leading Axle
Trailing Axle

Hunting

Right wheel pushing to left

Left wheel
pushing to left

Lateral forces

4000 lbs

8000 lbs

<- Gage Spreading Force ->

-- Vertical Left(near side)
-- Vertical Left(near side)

<- Lateral Left(near side)
<- Lateral Left(near side)

Lateral Right(far side) ->
Lateral Right(far side) ->

Vertical Right(far side) --
Vertical Right(far side) --

5

GAP

6

GAP

5
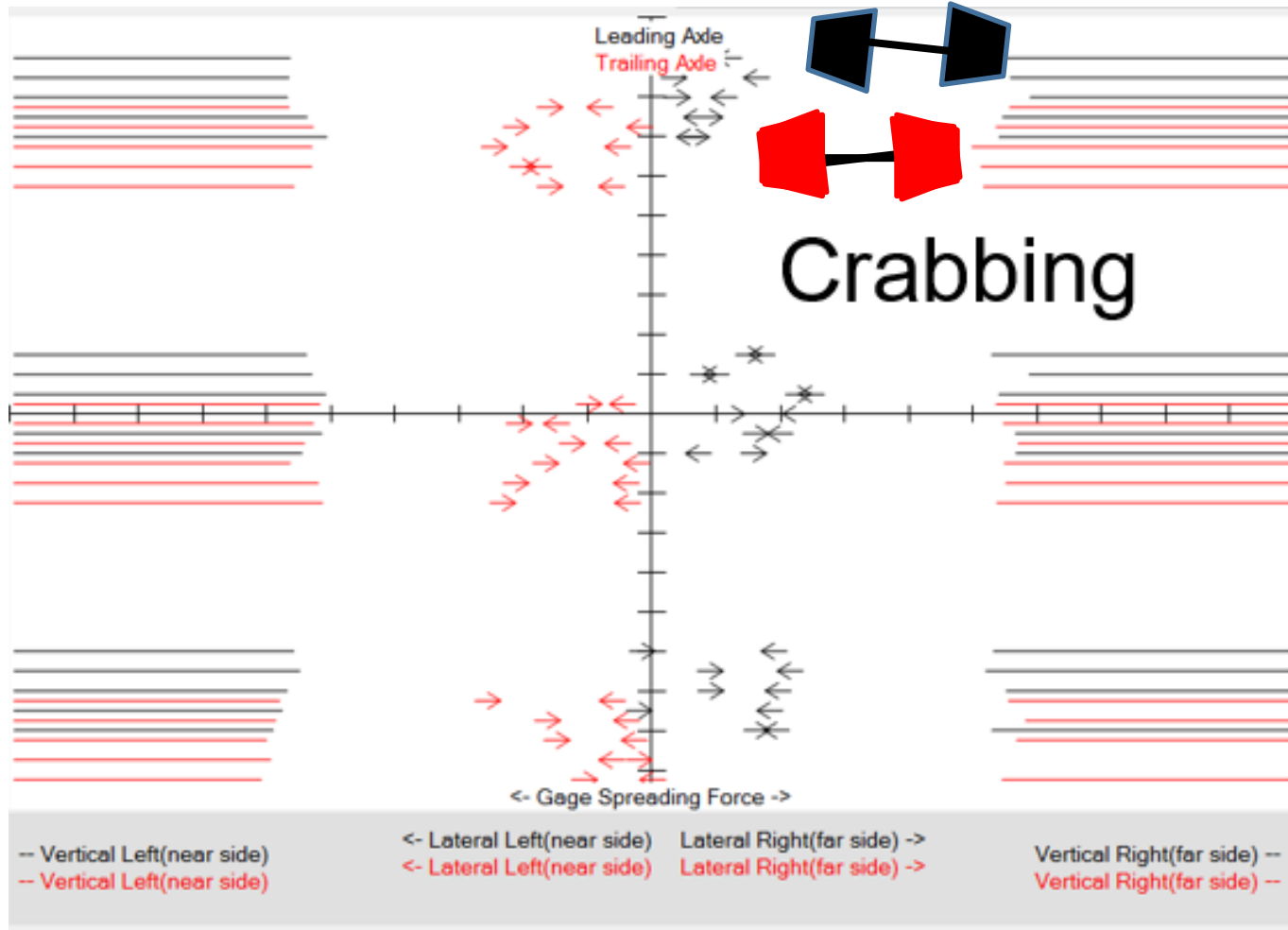
- Layout 5/6/5
- Vertical from Sides
- Lateral from Center
- Lead/**Trail** Axle
- ← Left (Wheel) Right →

Instrumented Wheelset Mirror

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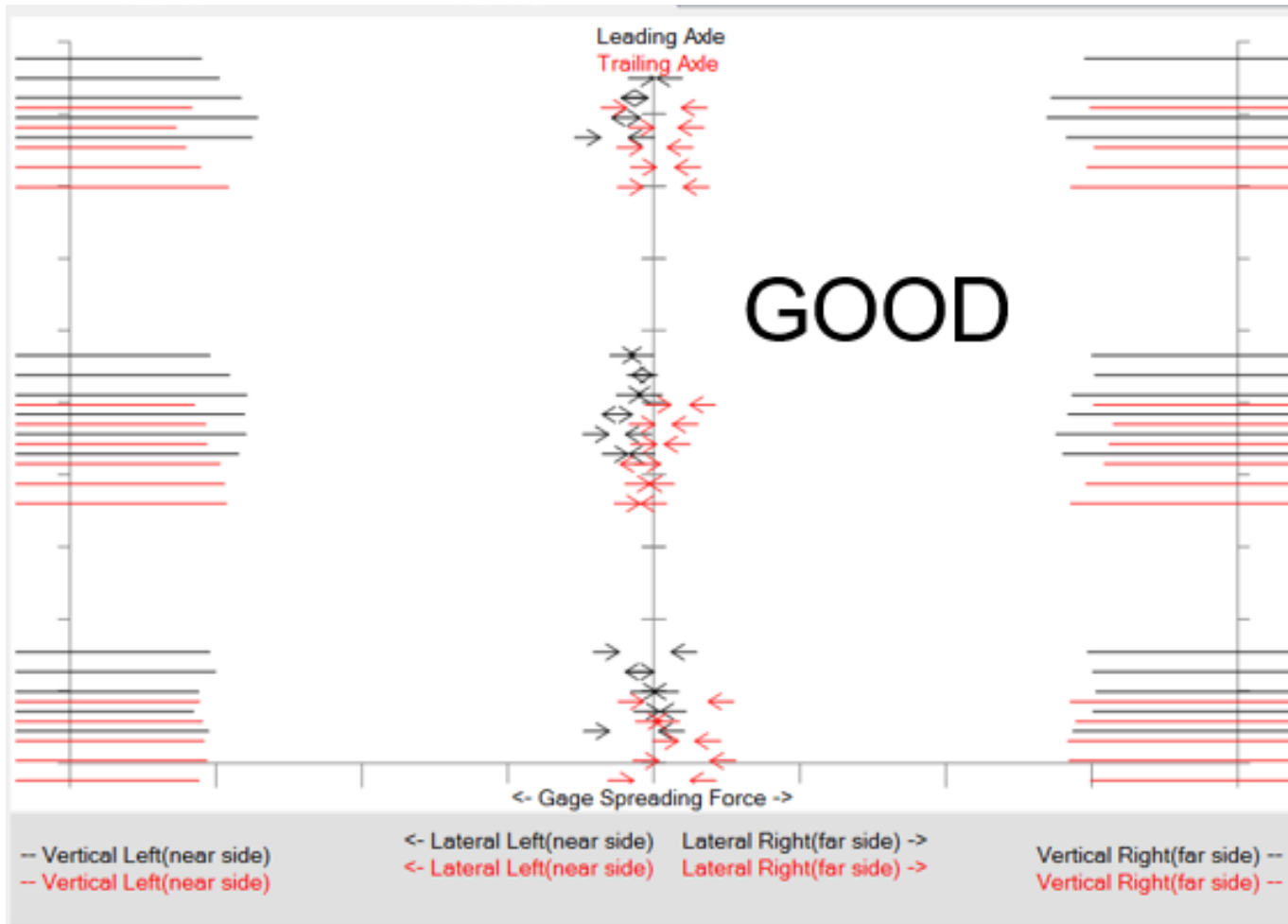WRI 2019

WILD Crabbing Truck Example

- Derailment Risk
  - Will it right itself?
  - Loading related?
  - Wheel Profiles?
  - Truck/Center Plate?
  - Coupler?
  - **Switch Point?**

This is just a training slide
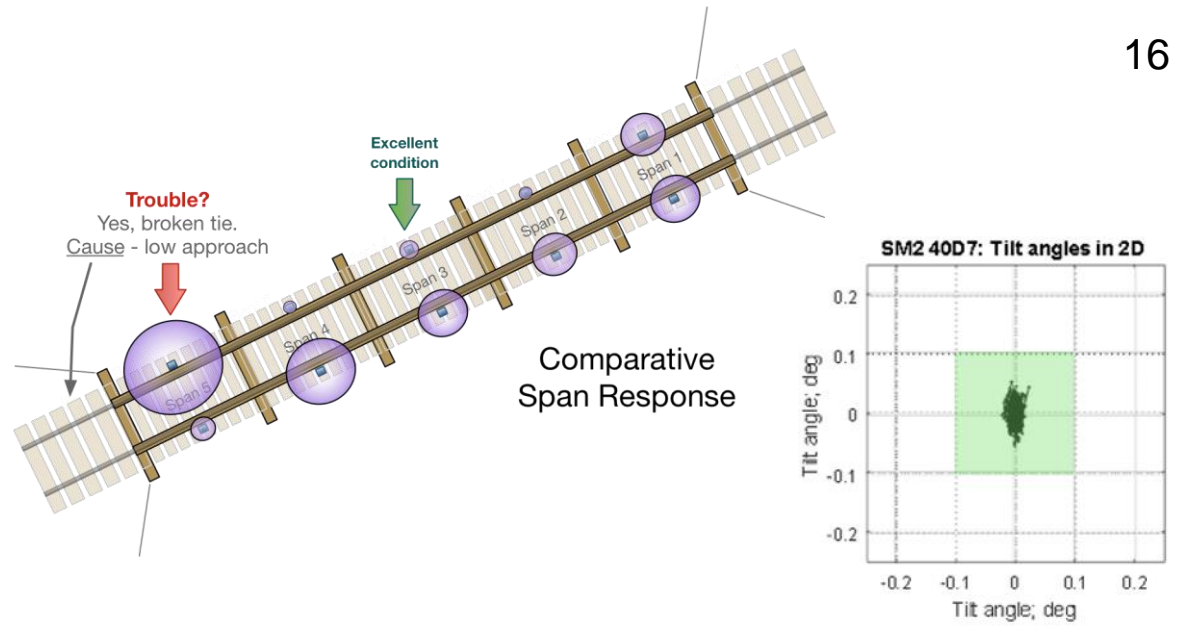
WILD 'Normal' Example

Leading Axle
Trailing Axle

GOOD

<- Gage Spreading Force ->

-- Vertical Left(near side)
-- Vertical Left(near side)

<- Lateral Left(near side)   Lateral Right(far side) ->
<- Lateral Left(near side)   Lateral Right(far side) ->

Vertical Right(far side) --
Vertical Right(far side) --

- Good Enough?
- Improvement with side bearing, adapter, side frame… ?
- Performance
  - In curves ?
  - Other speeds ?

Work to do

Bridge Motes/IoT

Trouble?
Yes, broken tie.
Cause - low approach

Excellent condition

Span 1
Span 2
Span 3
Span 4
Span 4

Comparative Span Response

SM2 40D7: Tilt angles in 2D

Tilt angle; deg

Tilt angle; deg

State of the Art ?

Heartbeat? Data Exploitation? Edge/Real Time? AutoCal? SaaS Back-end? Global ID, Error Handling?

Axle Spacing

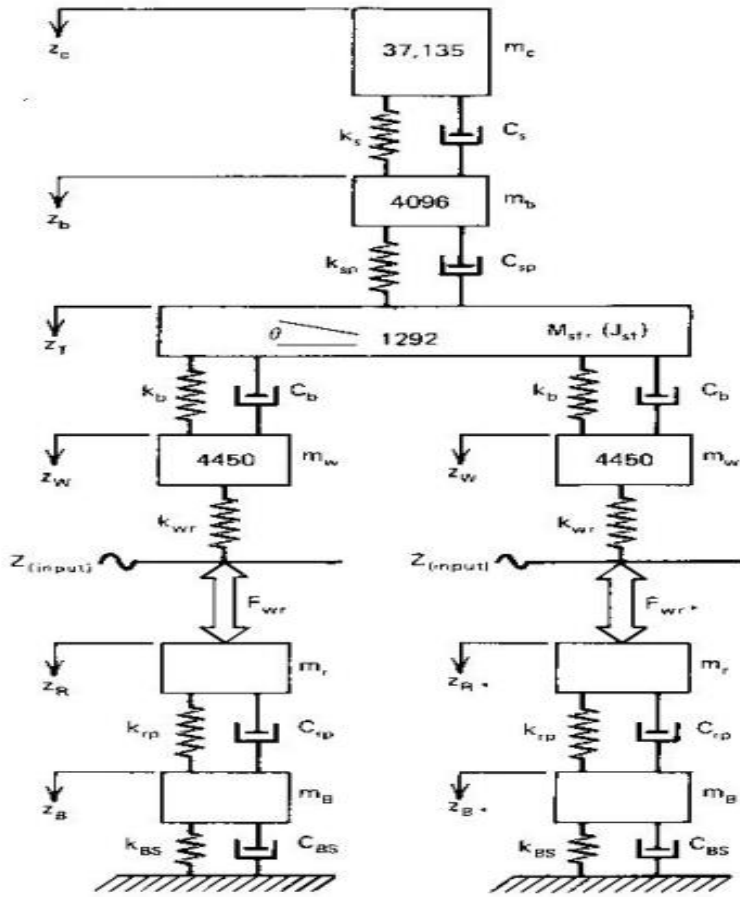LOCO LOCO LOCO   5-PAK   3-PAK 2-PAK

Axle In Train
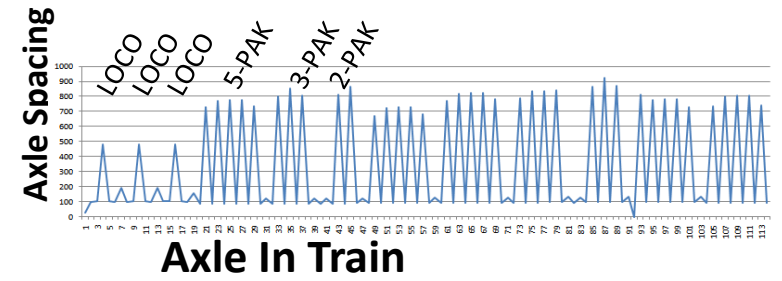
Automated Vehicle and Track Inspection Systems

- Adoption
  - Unregulated: ABD 1-6, WILD, VTI, MV?
  - Regulated: UT, Brake Tests, MV?

Goal: Understand Reality   Improve Safety/Efficiency

Questions ?