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Derailment Prevention Strategies

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Today's Webcast starts at 1:00 p.m. Eastern.

You will not hear audio until the Webcast begins

Today's Moderator

Julie Sneider
Assistant Editor
Progressive RAILROADING

Today's Presenter

Gary Wolf

President and Founder,
TUV-Rail Sciences Inc.

The accurate determination of derailment causes and the prevention of recurrences have been the driving passion of Gary Wolf's railroad life for the past 37 years. He has taken part in the investigation of over 4000 individual derailments, and has been the lead investigator on numerous high profile derailments. His derailment investigation and training work has carried him to every continent except Antarctica, and every type of rail system from Class 1 heavy haul, transit, and narrow gauge underground coal haulers. Gary has presented over 100 technical papers and articles dealing with derailments and track/train dynamic issues. He is a member of the ASME Rail Transport Division General Committee, AREMA, The Air Brake Association, and was elected President of the International Railway Operating Officers Association for 2005-06. In addition, Gary served on numerous AAR committees during the Track/Train Dynamics research program of the 70s and 80s.

Gary Wolf received a BS Electrical Engineering from Ohio University and a MS from Georgia Tech. He began his railroad career in 1970 in the Mechanical Engineering Dept. with Southern Railway. In 1976 he was appointed to a new position as a track/train dynamics engineer in Southern's Operation Research Department. At this time he became responsible for the study and analysis of Train derailments and accident investigations, Track/train dynamic Studies, New locomotive and car technologies, and Rail Capacity Studies. In 1987 he left Norfolk Southern and founded Rail Sciences Inc. For the past 25+ years he has been president of Rail Sciences. In 2010 Rail Sciences was acquired by TUV-Rheinland, a German based Engineering and Testing firm, with a global rail practice.

To Ask Questions

Please use the question and answer panel on the right-hand side of the screen and send to all panelists.

Polling Questions

Today's event will include a series of multiple-choice polling questions. Your participation is appreciated.

Presentation Handouts

All participants will receive an e-mail by the end of the day with a link to download a PDF copy of today's presentation slides.

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- Go-Team ready for on-site investigation
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- Specialists in Simulation Analysis
  - Longitudinal Train forces using TOS or TOES
  - Vehicle dynamics using VAMPIRE
  - Finite Element Modeling using Abaqus
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One Source to the Railroad Industry

Derailment Prevention Strategies

Prepared for:

Progressive Railroad Webinar

March 14, 2013

Prepared by:

Gary P. Wolf

President

TUV- Rail Sciences Inc.

Atlanta GA

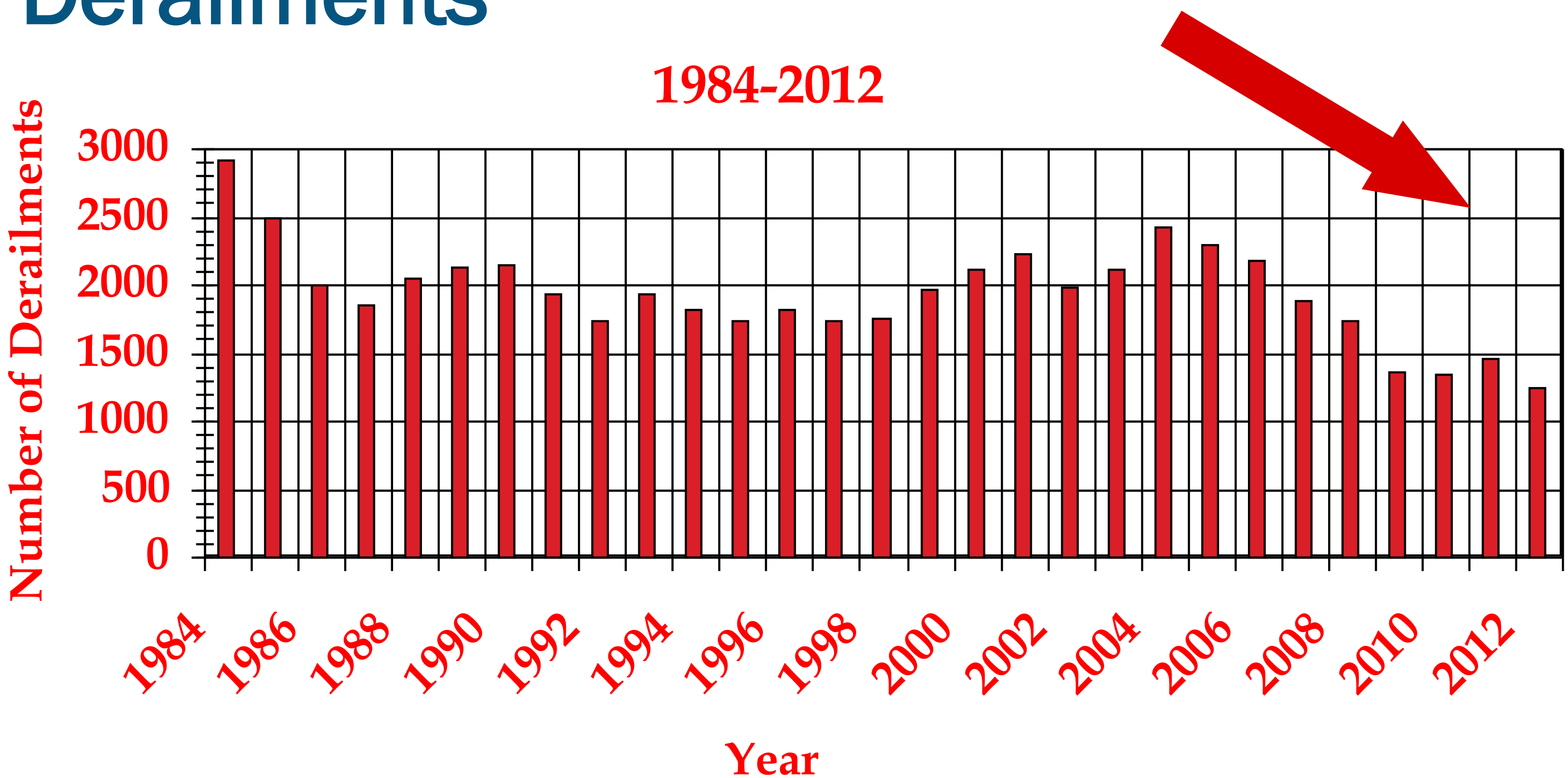
Presentation Overview

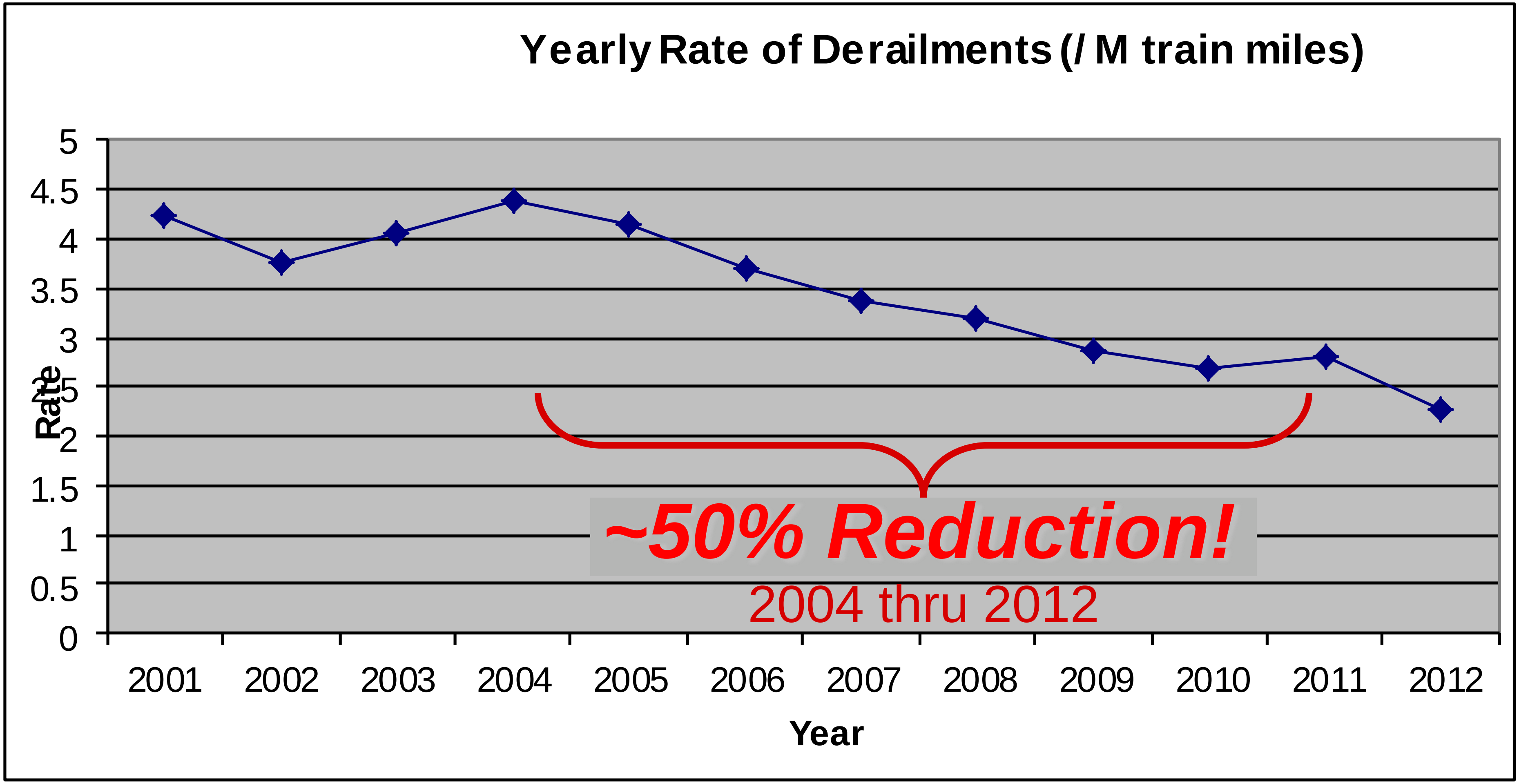
- Review statistical trends and reasons for trends
- Discuss need for a dedicated corporate focus on derailment prevention
- Emphasize need for accurate root cause analysis
- Discuss modern tools to assist in root cause analysis
- Review fault detection technology for track, equipment and human factors
- Review need for science based train handling and train make up rules
- Explain modern method for performance based derailment risk assessment

Let’s start with Good News!

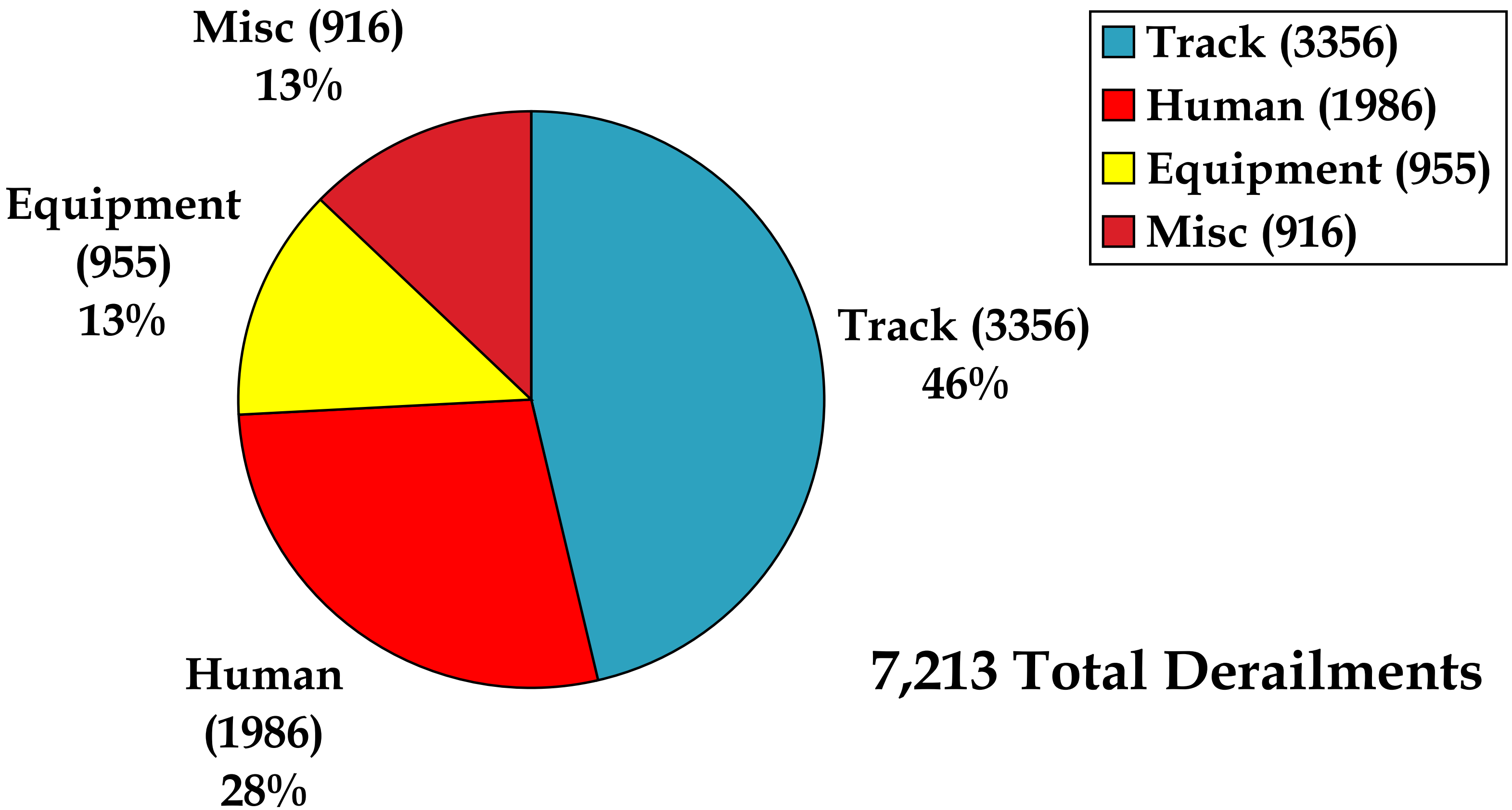
Derailments and Derailment rates have dropped dramatically over the past 8 years

U.S.A. Total Number of FRA Reportable Derailments



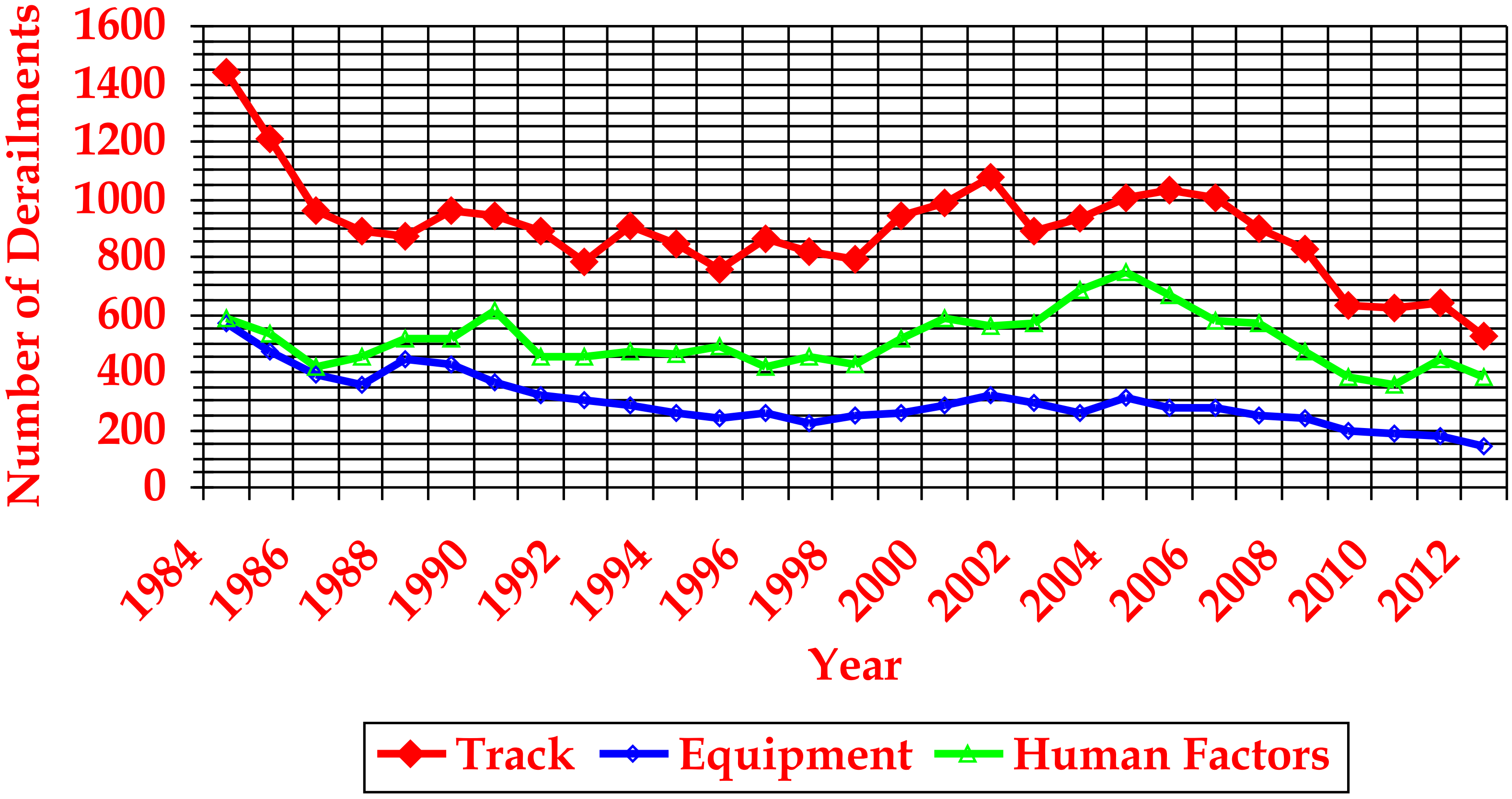

Yearly Rate of Derailments (/ M train miles)
Rate
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year
~50% Reduction!
2004 thru 2012

4 Years of FRA Reportable Derailments 2006 -2009



7,213 Total Derailments

1984-2012 FRA Reportable Derailments by Cause



Conclusions from Statistical Trends

- We have made good progress over the past 7 years; but much work remains
- Over 50% of reportable derailments occur at speeds under 10 MPH, and the majority of those derailments occur in yards.
- The majority of derailments are track related; wide gage single biggest cause in FRA database
- Mechanical conditions, either causative or contributory, in derailments may be under-reported due to lack of understanding of truck dynamics.
- We have made very little progress in reducing human failures. Most of the reductions have been in track and mechanical causes.

Additional Conclusions from Derailment trends

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- Many FRA cause codes not definitive (e.g., truck hunting, harmonic rock/roll, track buckle, wide gage, etc.) as to root cause.
- The data clearly shows a significant improvement over past 8 years in both actual number of derailments and the rate per million train miles.
- Many reasons for the 6 year reduction:
  - Better components and materials
  - Better fault detection
  - Better cause finding thru better training
  - Increased focus on the problem at many RR's
  - Better standards and compliance to standards

Let’s review some of the reasons for the dramatic reduction in derailments…

Improvements in Track Standards/Maintenance

- Harmonic Rock/Roll crosslevel geometry (CFR213.63)
- Additional crosstie requirements for curves and turnouts (CFR213.109)
- GRMS testing for lateral track strength (CFR213.110)
- Joint Bar inspection requirements in CWR Territory(CFR213.119)
- CWR Maintenance Procedures (CFR213.119)
  - Improved Rail Anchoring in turnouts
- Better Rail Profile Grinding
- Rail Lubrication systems; Gage Face and Top of Rail
- Improved Automated Track Inspection and Testing
  - Geometry (Rail Car and Hy-Rail, ENSCO, Mermec, Andian)
  - Rail Flaw (Sperry, Herzog, Nordco)
  - Track Deflection (TUV-RSI Mrail)
  - GRMS (Holland Track Star)
  - Longitudinal Rail Stress/Rail Neutral Temperature (Vortok VERSE)
  - Machine Vision Tie Inspection (Georgetown Rail AURORA)

Improvements in Mechanical Standards/Maintenance

- AAR Rule 46 on truck performance
- AAR Rule 62 Codification of constant contact side bearing maintenance and inspection
  - Requirement for Long Travel CCSB
- Hollow wheel wear – AAR Rule 41
- Detector Technology
  - WILD
  - TPD
  - Truck Hunting
  - Angle of Attack (AOA)
  - Automatic Wheel Profile Measurement
  - Temperature Trending for roller bearings

Improvements in Human Factor Causes

- Switching Operations Fatality Analysis (SOFA)
- New CFR 49 Sections
  - 217 – Railroad Operating Rules
  - 218 – Railroad Operating Practices
- More emphasis on Rules Testing
- Better Training; use of simulators
- Use of RCL technology
- Federal Certification Programs
  - 240 – Engineers
  - 242 – Conductors
- Drug and Alcohol Testing Programs
- Event recorders; Video camera systems

Final Conclusions

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- Many of these improvements create synergistic improvements across the entire spectrum of a railroad's infrastructure.
- It is incumbent upon each railroad to apply and comply with these improvements in order to take full advantage of the benefits.
- We still have a ways to go…We are not finished yet!

Polling Questions

Your participation is appreciated

Steps to keep this trend going…

1. Corporate Focus
2. Improved Cause Finding Techniques
3. Deployment of Detection and Inspection Technologies
4. Development of proper Train Handling and Train Make-Up Rules
5. Application of Quantitative Derailment Risk Assessment Tools

Corporate Focus

- Corporate ownership of Derailment Prevention
  - Need a champion, a mentor, to coordinate efforts and take ownership within the corporation.
  - Neutral reporting relationship to avoid bias
  - Establish accountability
  - Establish Mission, Goals, objectives, and strategy
- Multidisciplinary derailment prevention TEAM.
  - Engineering, Mechanical, Operations, Safety, Signal, others
  - Revolving leadership (CSX TAP concept good model)
- Divisional field teams
- Statistical Analysis
  - "if you can't measure it…you can't manage it"
  - FRA reportable and Non-reportable
  - Must assign accurate cost of failure taking into account <u>all</u> costs

Derailment Prevention Starts with Accurate Cause Finding

Accurate cause finding prevents a recurrence of another derailment on that section of track, or with that particular vehicle or vehicle type, or with that particular crew.

Why Study Derailments???

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"Progress, far from consisting in change, depends on retentiveness. Those who cannot remember the past are condemned to repeat it."

-George Santayana

Accurate Derailment Cause Finding

- Unbiased, Multiple Disciplinary Approach
- Timely Investigation and follow-up
- Objective and data driven
  - Simulation analysis
  - Metallurgical analysis
  - Event recorder data
- Targeted Corrective Actions
  - Cost Effective
  - Within Corporate capabilities
  - Check for unattended consequences

Cause Finding Caveats

- Most derailments have multiple causation; Rarely one single cause
  - Must determine primary or root cause
  - Must also address all contributory causes
- May not find a direct violation of AAR, FRA, or Operating Rules
  - Standards don't cover everything
  - Standards don't take into account multiple deviations between and within standards
  - You may have discovered the need for a new standard or rule; standards and rules need periodic updating
- The greater the number of deviations from standards that you allow, the higher the probability of a derailment

Trends in Derailment Cause Finding

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- Due to downsizing, privatization, attrition, and retirements, the industry knowledge level has declined considerably
- Better training and tools are required for modern derailment investigation

1. Identify P.O.D.

10 Step Cause Finding Process

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2. Identify First Derailed Wheel

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4. Determine Wheel Action

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3. Note where lead loco stopped
4. Determine Wheel Action
5. Determine Exception to Standard

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4. Determine Wheel Action
5. Determine Exception to Standard
6. Obtain Simulation Analysis

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7. Obtain Metallurgical Analysis
8. Develop Consensus Cause
9. Implement Corrective Actions
10. Monitor Corrective Actions

10 Step Cause Finding Process

Tools to Improve Accident Investigation

- Simulation Analysis
- Metallurgical verification of suspected defects
- Miniprof/Lazerview wheel and rail profiles
- Laser Measurement of Rail Profiles
- Wayside detector data (WILD, TPD, Hotbox)
- Event recorder data; video cameras
- Mobile Dynamometer Test Car
- Track Strength Measurement tools; GRMS
- Digital Tribometer Rail Friction Measurement
- Track Recording Car Geometry Analysis

Computer Simulation of Derailments and Vehicle Dynamics

- Train Operations Simulator (TOS)

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- Derailment Predictor Model (DPM)

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- Quasi-Static Lateral Train Stability (QLTS)

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Advantages of Simulation

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- Removes Opinions and Biases
- Consistent Methodology

Deployment of Advanced Detection, Inspection, and Measurement Technologies

Advantages of Automated Inspection

- Consistent application of standards and methodology
- Accurate day in and day out
- Works in all kinds of weather or lighting conditions
- Eliminates "good day/bad day" behavior of humans
- Creates a data trail
- Can cover far more assets than visual inspections
  - Every wheel, every car, every inch of track
- Cost effective
  - Can eliminate costs and safety consideration of human inspection
  - Can reduce required terminal or track time; improves capacity

Wayside Detection Technology

- Wheel Impact Load Detector (WILD)
  - Senses wheel flats; out of rounds
  - Can sense load imbalance and overload conditions
- Truck Performance Detector (TPD)
  - Measures lateral wheel forces to detect poor steering trucks (bad actors)
- Hunting Detector
- Wheelset angle of attack (T-bogie)
- Hot/Cold Wheel detectors
- Hot Box Detector
  - Absolute temperature alarms, Temperature Trending pioneered by UP
- Automated Wheel profile measurements
  - Finds FRA/AAR defects; can be used to detect asymmetrical wear patterns
- Machine Vision Systems
  - Can detect low air hoses, high wedge rise, brake shoe wear, coupler retaining pins, safety appliance defects

Track Inspection Technologies

- Automated track geometry measurements
- Rail Flaw detection; Ultrasonic and Induction (new laser system on horizon)
- Automated joint bar inspection using machine vision
- Automated crosstie and fastener inspection using machine vision
- Rail Neutral Temperature (RNT) measurement using VERSE
- Rail stress measurement using strain gauges
- Lateral Track Strength Testing (Holland Trackstar GRMS)
- Automated Rail Wear and Profile Measurement
- Automated Rail Cant Measurement
- High speed tribometers to measure rail friction
- Automated high speed Track Deflection testing (Mrail)
- Ground Penetrating Radar (GPR)

On-board Monitoring and Control

- Solid State, crash hardened multi-channel event recorders
- On-board video cameras
- Vertical Track Interaction (ENSCO VTI)
- Train Handling Assist Programs (NYAB LEADER; GE Trip Optimizer)
- On-board Asset Monitoring (Amsted IONX)
- Car borne detectors and monitors
  - Hot box
  - Derailment detection
  - Lateral and vertical accelerations
  - Impact detection
  - Temperature monitoring
  - Braking defects (in conjunction with ECP brake systems)

Other technologies to reduce derailments and accidents

- Distributed Power (Locotrol)
- ECP Braking
- Train Link ES
- Remote Control Locomotives
- Positive Train Control (PTC)
- Improved turnout target visibility
- Electronic control turnouts

Provides high visibility reflective indication of switch point position.

Run through Switch Indication

Aldon Company Inc.

Switch Cube™ Indicator

Aldon Company Inc.

Switch Cube™ Indicator

VIEWED from “FROG” END

Lined for Main

Lined for Turn Out

Control of In-train (Drawbar) Forces

In-train forces are additive to all the other forces occurring at the wheel/rail interface.

High or Excessive in-train forces can cause a marginally stable vehicle to derail on marginal track conditions.

Every effort must be made to minimize the development of excessive drawbar forces (static & dynamic), and to limit the development of excessive lateral forces due to coupler angularity

Train Handling and Train Make Up Rules

- Must limit traction and dynamic braking forces consistent with the strength of the track structure.
  - Powered axle limitations
  - Proper tonnage limits for the territory
  - Prescribed train handling rules for difficult territories
  - Prescribed air brake rules
- In undulating territory, moderate reductions in speed can dramatically reduce slack action due to kinetic energy in train
- Speed limits for certain vehicles (empty tanks, bulkhead flats, centerbeams)
- Proper trailing tonnage limits behind empty vehicles
  - Based on maximum curvature on route
  - Based on expected buff and draft forces
  - Based on long-car short car coupler limits
- Restrictions on number and placement of EOC units
- Restrictions on placement of doublestack and spine cars; loading definitions on platforms
- Restrictions on number of non-alignment locomotives in consist

Performance based derailment risk assessment is available now to allow you to target high risk locations in the track, high risk equipment, or marginal operating practices.

Allows you to focus on the critical few rather than the trivial many. Also, allows you to factor in multiple defects that fall below conventional defect thresholds.

Derailment Risk Assessment Overview

- ***Problem*:** Many derailments are not caused by single factors, but are caused by multiple factors working in combination.
  - Multiple track defects in succession
  - Interaction of marginal vehicle and track characteristics
  - Marginal train handling, speed control, train make up

- ***Problem***: Current measurement techniques and rules intended to prevent derailment do not consider interaction of all factors, and do not prioritize maintenance practices as well as they could.
  - i.e. FRA condemnable thin flange wheel **does not** guarantee derailment.
  - i.e. track geometry measurements give too many defects; not all defects can be fixed.

- ***Solution***: Use industry **measurement systems** along with **computer simulation** to take **ALL FACTORS** into account and predict derailment and schedule maintenance practices accordingly.

Why Worry About Risk Assessment?

- All derailments are considered undesirable; however, some have extreme risk and/ or cost which would make **Risk Assessment** cost effective.
- Some trains present high risk
  - Passenger/Transit
  - HAZMAT
  - Intermodal
  - Perishable
- Some locations present high risk
  - Waterways
  - Tunnels
  - Bridges
  - Urban areas

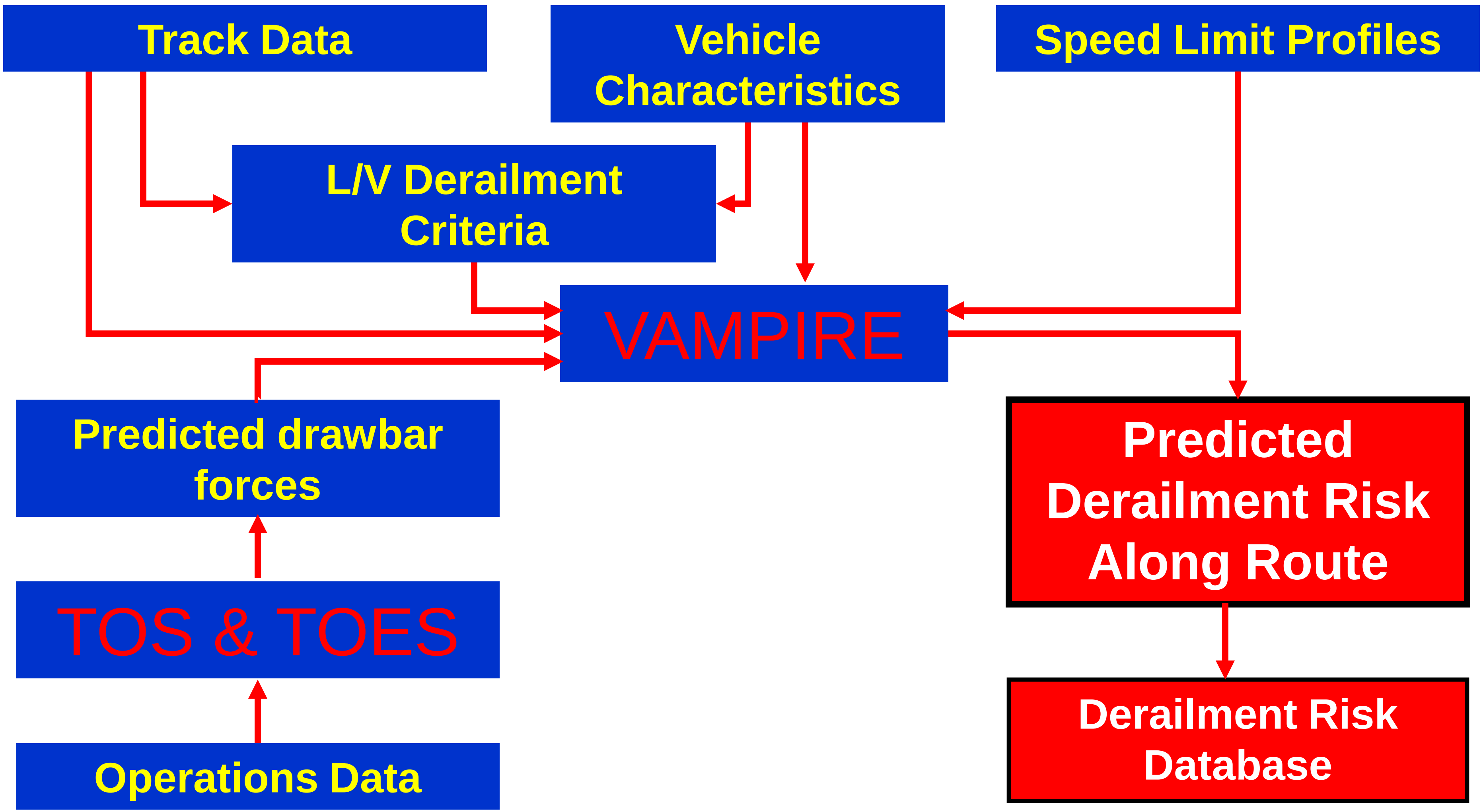
Background: Computer Models

- <u>Longitudinal In-Train Force Simulation</u>
  - Train Operations Simulator (TOS)
  - Train Operations and Energy Simulator (TOES)
  - Simulates in-train forces of model train consist, train handling, and terrain.

- <u>Vehicle Dynamics Simulation</u>
  - VAMPIRE
  - Simulates vehicle – track interaction, wheel – rail interaction
  - Outputs:
    - Vertical and Lateral Wheel Loads; percent unloading
    - L/V ratios (single wheel, truckside, axle sum)

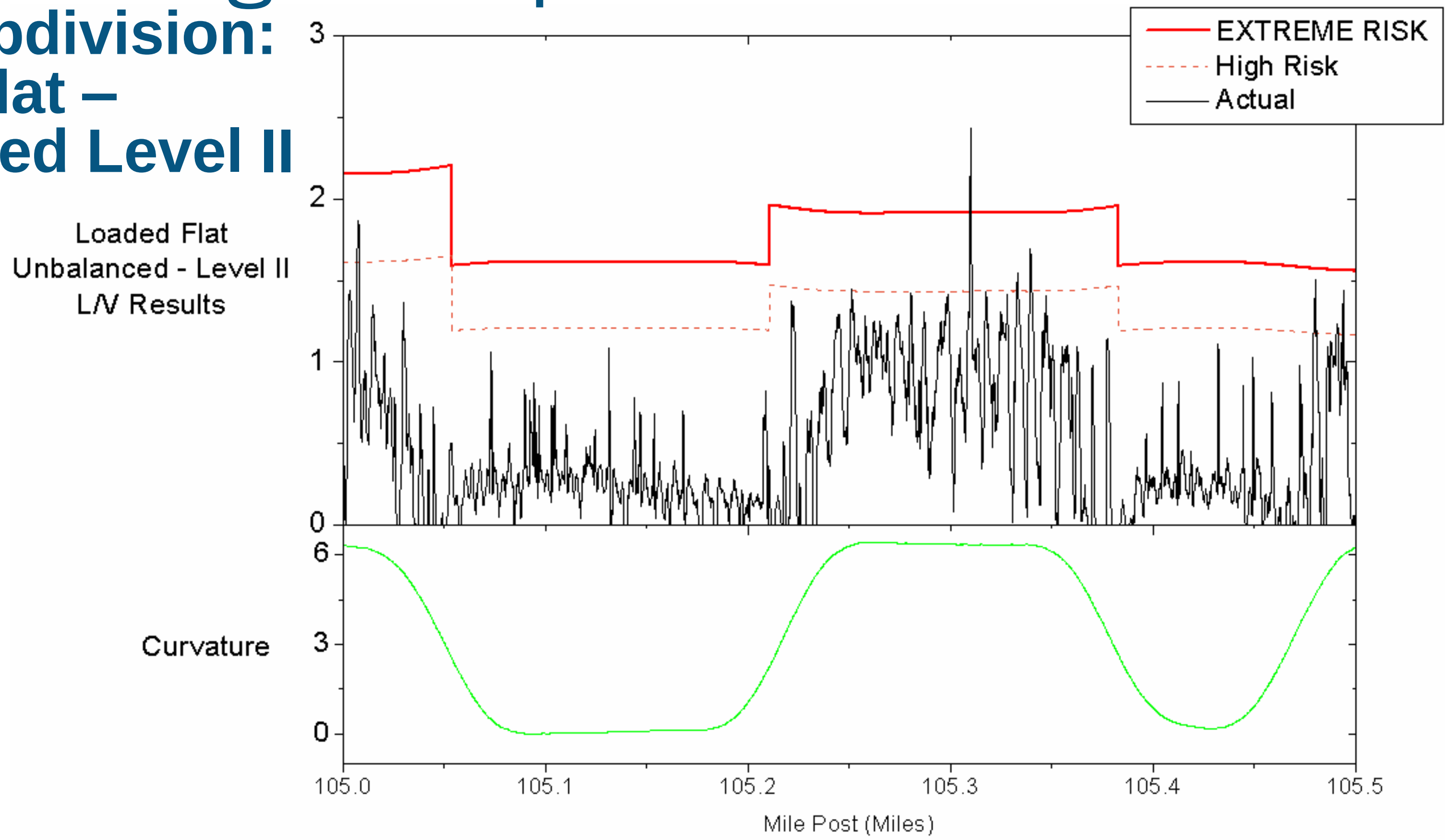
Concept Overview

- Compile data to characterize:
  - Track (i.e. Track Geometry Car Data)
  - Rolling Stock (i.e. Wayside detection)
  - Operations (i.e. Speeds, Operating practices, Train Make-up Rules)
- Enter all characteristic data into computer models that predict derailment risk.
  - Develop dynamic L/V thresholds along the route
  - Develop most probable applied loads (Lateral, Vertical, L/V) along the route
  - Use TOS, TOES, VAMPIRE to predict actual operating load regimes
- Provide simulation results to predict derailment risk and maintenance schedules.


Track Data
Vehicle Characteristics
Speed Limit Profiles
L/V Derailment Criteria
VAMPIRE
Predicted drawbar forces
TOS & TOES
Operations Data
Predicted Derailment Risk Along Route
Derailment Risk Database

Total Modeling: Example

Suffix Subdivision: Loaded Flat – Unbalanced Level II



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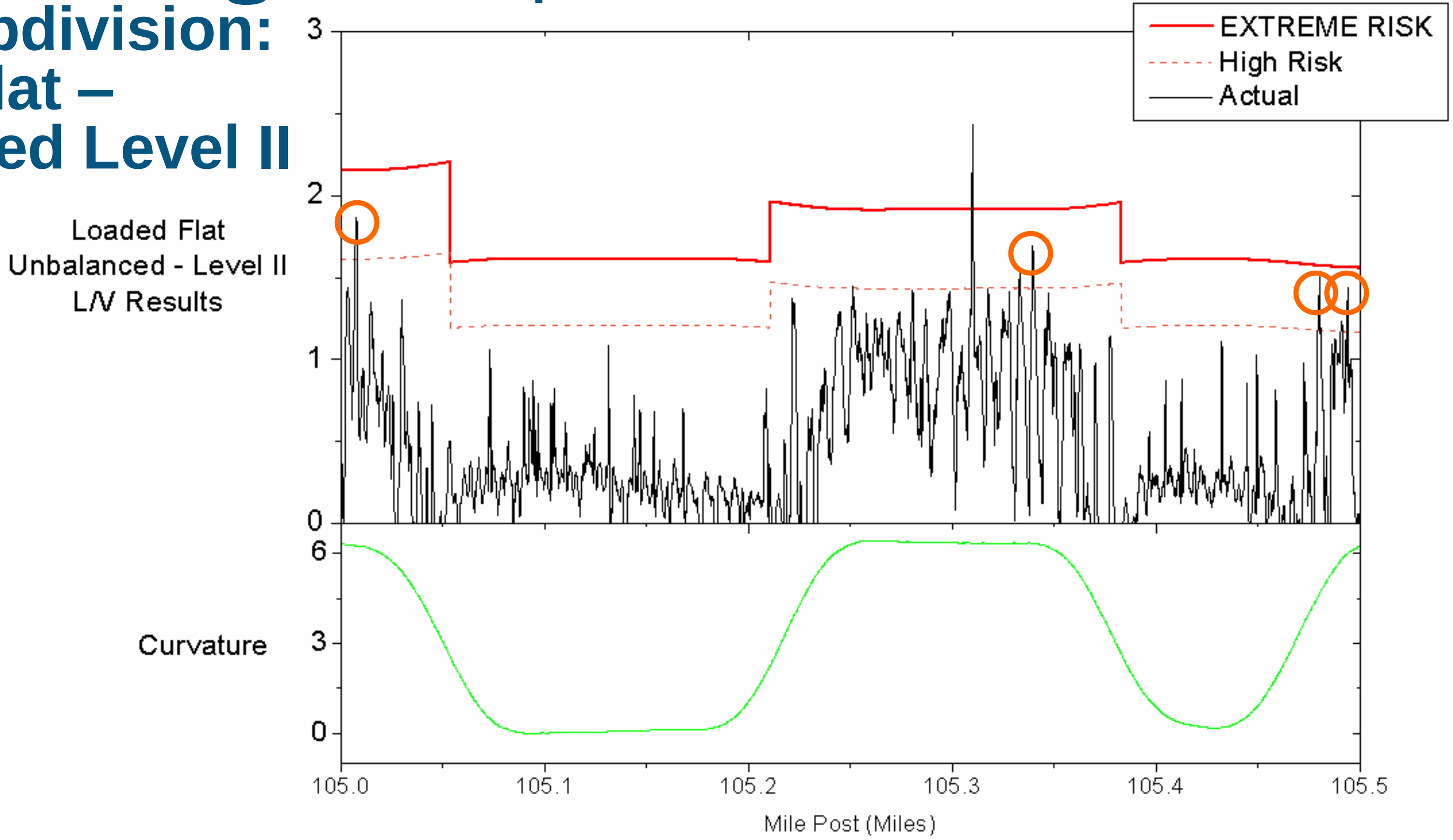

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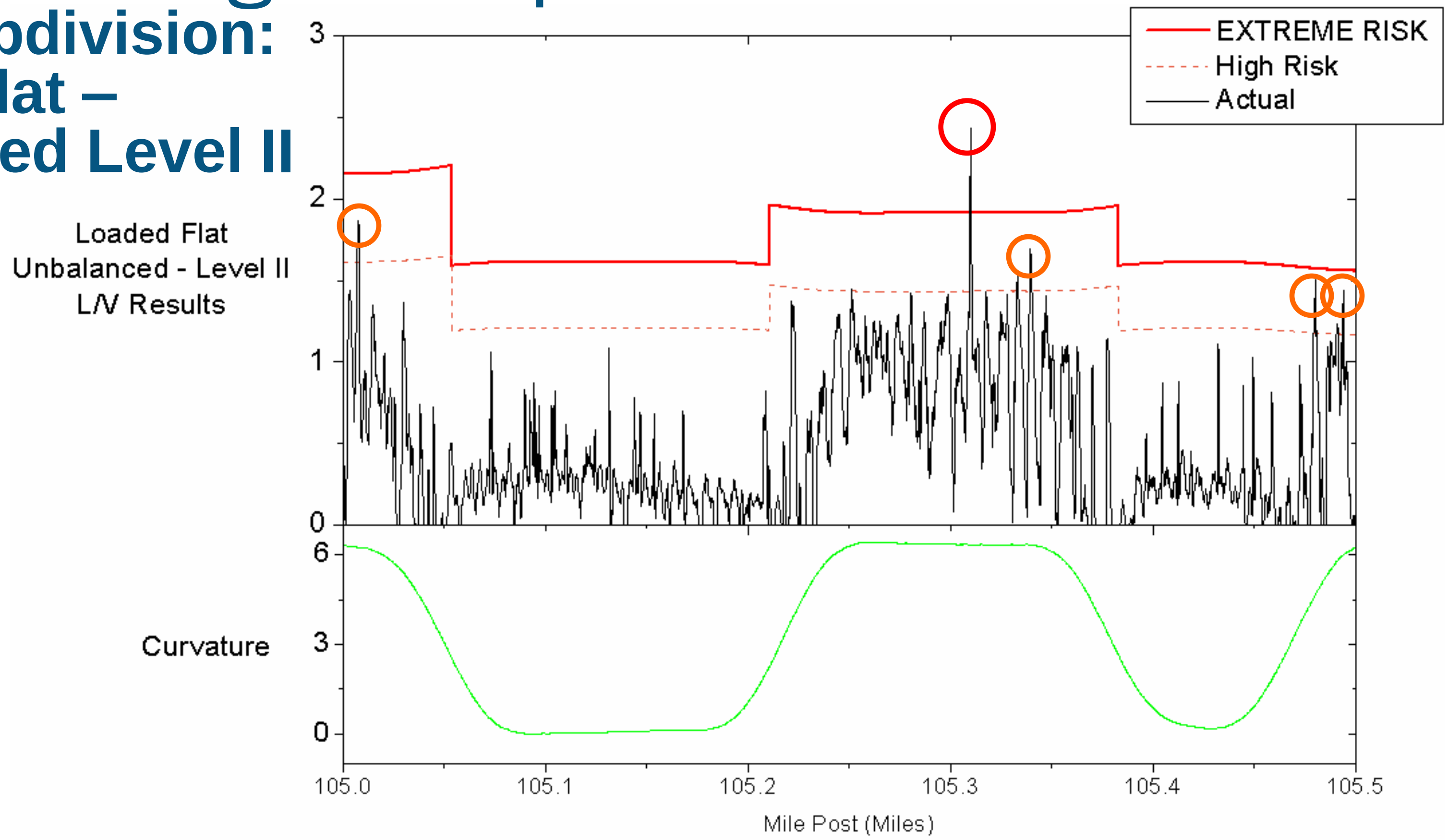


Track Modeling

Track Model Features:

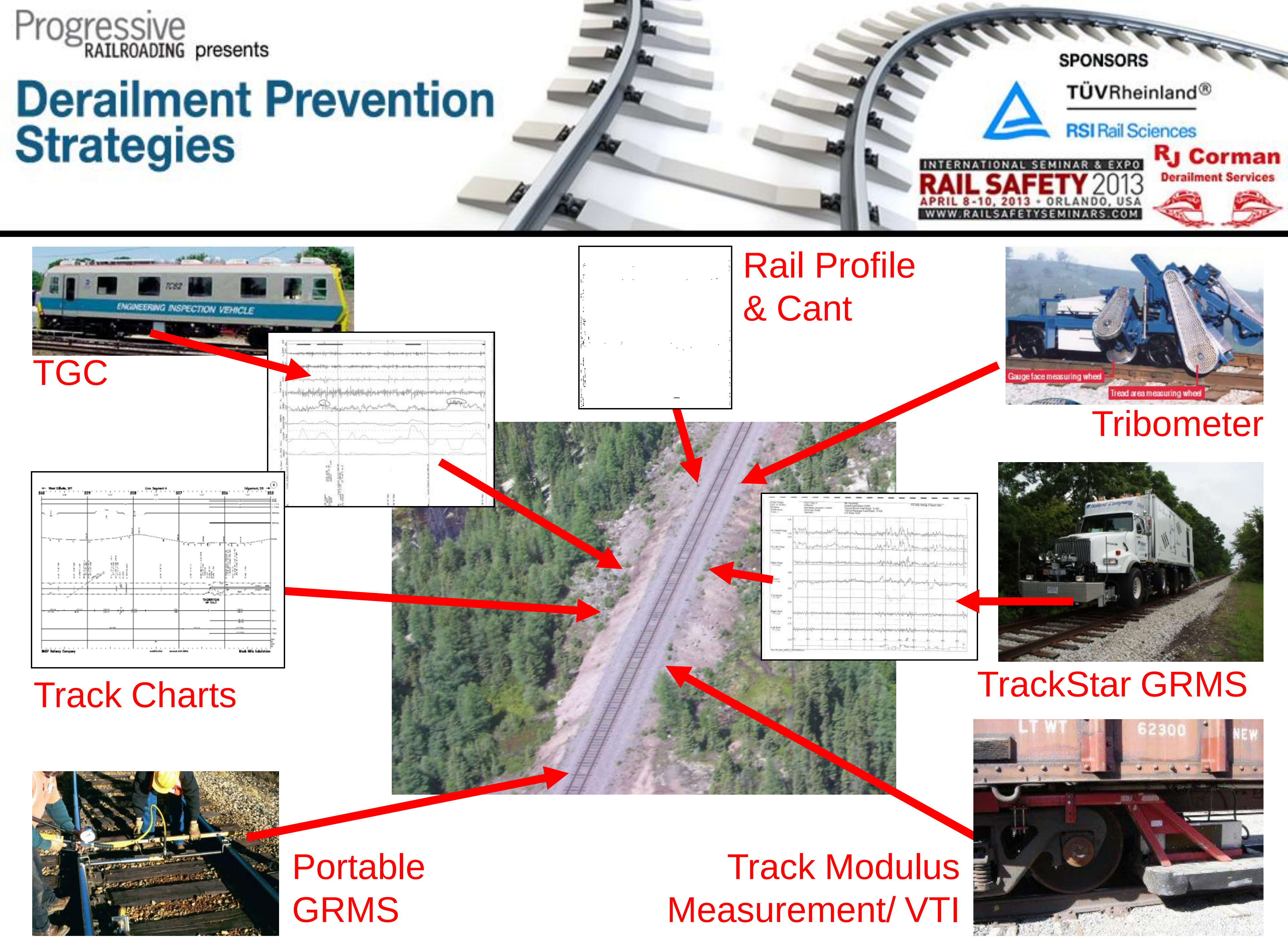
Curvature
Crosslevel
Gage
Vertical Profile
Lateral Alignment
Rail Profile and Cant
Top-of-Rail & Gage Friction
Vertical Track Modulus
Lateral Track Restraint

Sources of Data:

Track Charts
Track Geometry Car
Tribometer
Track Modulus Measurement

VTI
GRMS

- Use track data to fully characterize actual track routes.
  - Simulate in 5, 10, or 25-mile increments.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Rail Profile
& Cant
Gauge face measuring wheel
Tread area measuring wheel
Tribometer
Track Charts
TrackStar GRMS
LT WT
62300
NEW
Portable
GRMS
Track Modulus
Measurement/ VTI

Vehicle Modeling

Vehicle Model Features:

Car Type
Overall Length/ Truck Center Dist.
Weight/ Shifted Load
Wheel Profile
Steering Characteristic
Vertical Suspension & Damping

Sources of Data:

UMLER
Wheel Impact Load Detector (WILD)
Truck Performance Detector (TPD)
Truck Hunting Detector
Wheel Profile Measurement
Wheel Set Angle of Attack Measurement

Machine Vision:
Friction Wedge Rise
Side Bearing Clearance/ Setup Height

Progressive RAILROADING presents

Derailment Prevention Strategies

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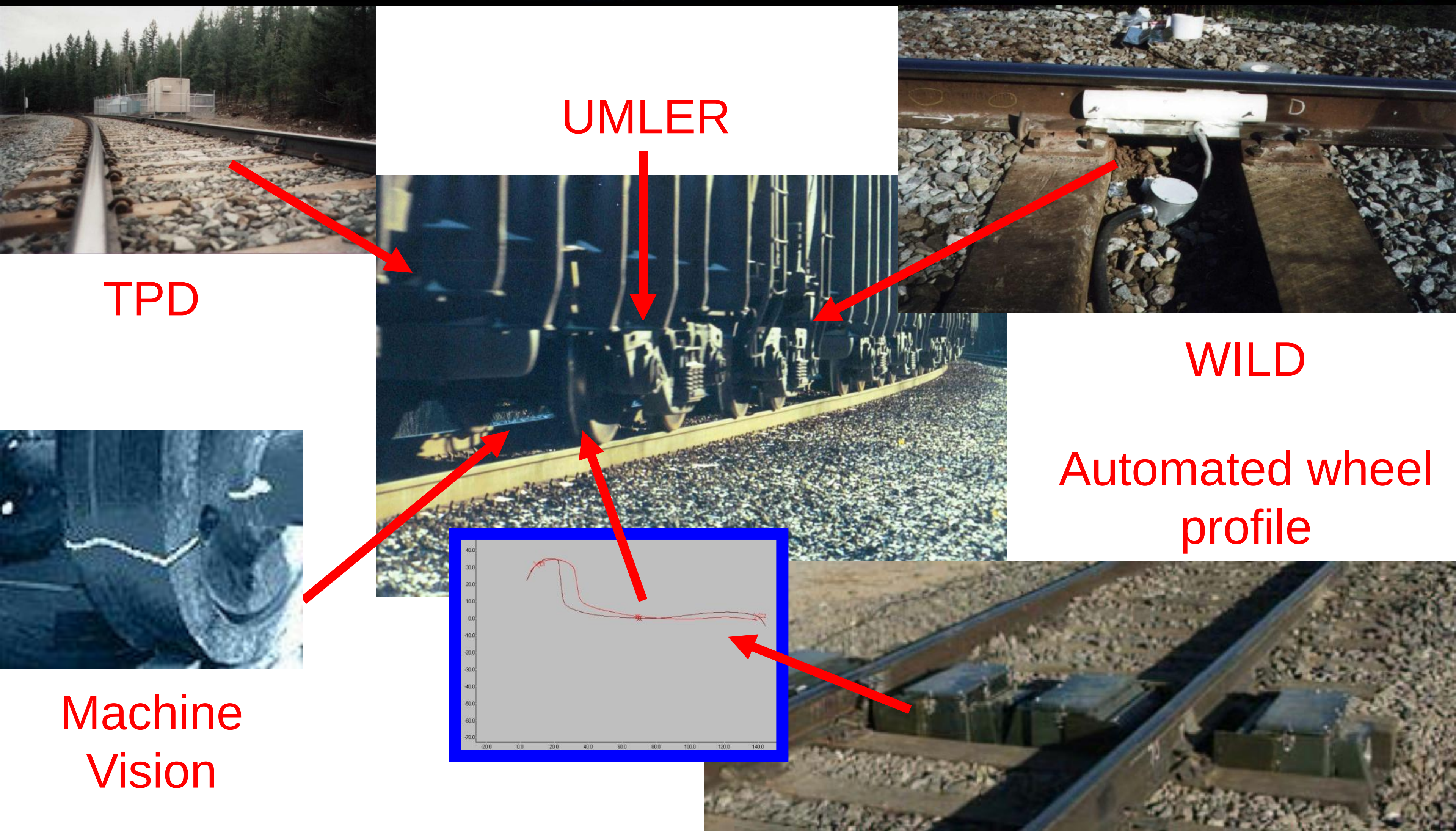

How to Start?

- Start Small
  - Passenger Transit / Captured Fleet
  - Start with Track Geometry Car Data and select car models.
  - Apply known data; assume typical values for missing data

Long Term Obstacles?

- Rail coefficient of friction changes.
- Need increase in measurement technology.
  - Track geometry car issues
  - Widespread Tribometer, Track Modulus, GRMS, mechanical wayside detection, etc…
- Increased computing power, data management
- Cost vs. Benefit

Final Conclusions

- We are doing good, just need to keep the trend moving downward with continuous quality improvement.
- Derailment prevention starts with dedicated corporate focus
- Accurate cause finding is essential
- Modern fault detection technology is essential in finding problems before they result in catastrophic failure
- Must have consistent and science based train handling and train make-up restrictions to limit stress environment
- Computer based derailment risk assessment takes advantage of all the data currently being collected and accurately defines risk based on performance rather than standards.

Questions?

Please use the question and answer panel on the right-hand side of the screen and send to all panelists.