OFFICE OF RESEARCH & DEVELOPMENT

2012 R&D REVIEW

Wayside Inspection Systems

MONIQUE FERGUSON STEWART
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Office of Research and Development
Office of Railroad Policy and Development

U.S. Department of Transportation
Federal Railroad Administration

Program Area & Risk Matrix
Wayside Inspection Systems

Program Areas \ Risk Factors	Trespass	Grade Crossing	Derailment	Train Collision	All Other Safety Hazards
Railroad Systems Issues					
Human Factors					
Track & Structures					
Track & Train Interaction					
Facilities & Equipment					
Rolling Stock & Components			X		
Hazardous Materials					
Train Occupant Protection					
Train Control & Communications					
Grade Crossings & Trespass					

U.S. Department of Transportation Federal Railroad Administration
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Wheel Temperature Detector Technology

U.S. Department of Transportation
Federal Railroad Administration

Acknowledgements & Stakeholders

Acknowledgements

- TTCI Engineering staff
- Union Pacific
- Norfolk Southern
- Canadian Pacific

Stakeholders & Project Partners

- Transportation Technology Center, Inc. (TTCI)
- Association of American Railroads (AAR)
- North American Freight Railroad Companies

Objectives

- Demonstrate the capability of wheel temperature detector technology to evaluate brake effectiveness by comparing relative wheel temperatures within a train
- Investigate the feasibility of using wheel temperature detector technology to determine air brake effectiveness under dynamic operations
- Investigate the correlation between piston travel and brake shoe force

Efforts are being conducted in co-operation with the AAR Technology Driven Train Inspection (TDTI) Strategic Research Initiatives

Objectives

- The Code of Federal Regulations, Title 49 Part 232.103, requires that every car in a departing train have an effective brake.
- CFR 49 Part 232.5 gives the following definition of an effective brake: *Brake, effective means a brake that is capable of producing its nominally designed retarding force on the train*
- Wheel temperature detector technology provides an indirect measurement of brake shoe force in a dynamic environment

Technology Evolution

- Current manual brake inspections rely on piston travel as an indication of brake effectiveness
- Brakes are tested in static environment
- The technology has been used extensively in the industry for many years to identify hot wheels and bearings (outliers on the high end when wheel/bearing temperatures are expected to be low)
- The premise is to identify outliers on the low end when wheel temperatures are expected to be high (under normal braking conditions)

How the Technology Works

Methodology:

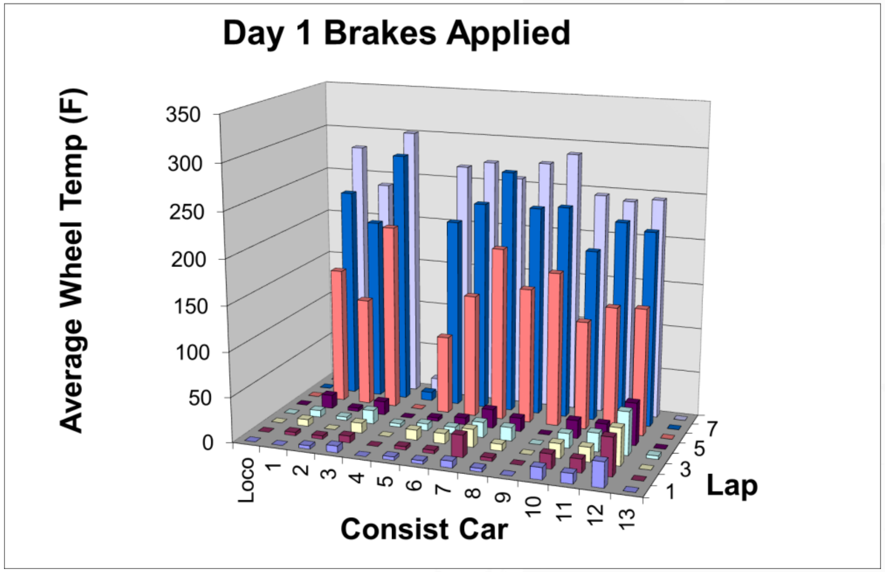
- Controlled testing at the Transportation Technology Center
  - Demonstrate capabilities
  - Investigate effectiveness of technology
  - Look at correlation between piston travel and brake shoe force

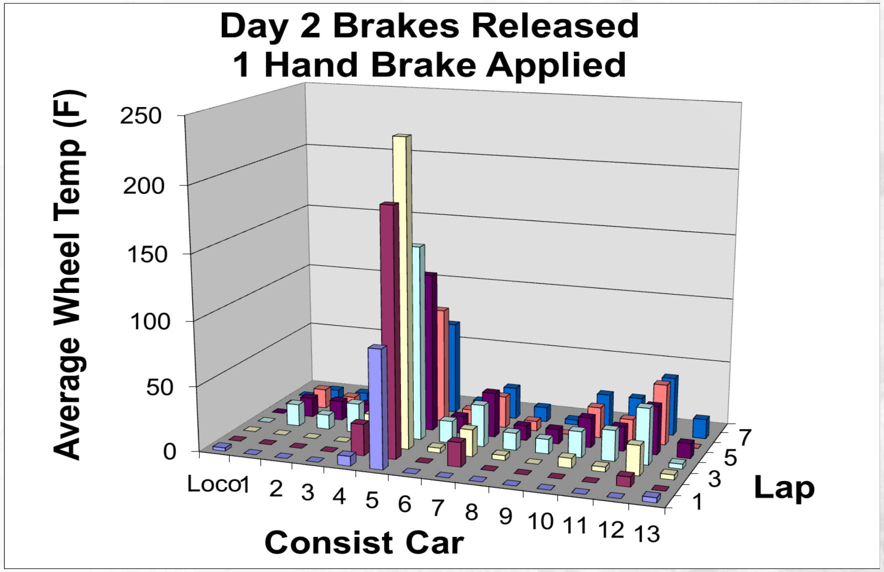
- Revenue service testing on Union Pacific Railroad
  - Benchmark manual inspection results
  - Determine failure rates found using technology

Results

Demonstration Testing at FAST

Technology was able to distinguish between applied and non-applied brakes for known braking conditions

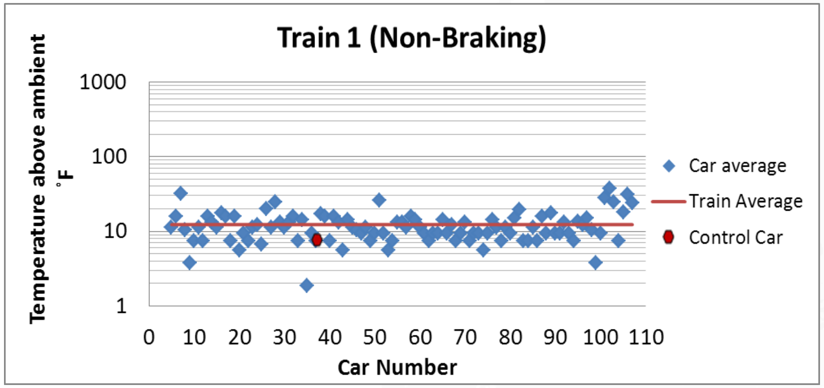


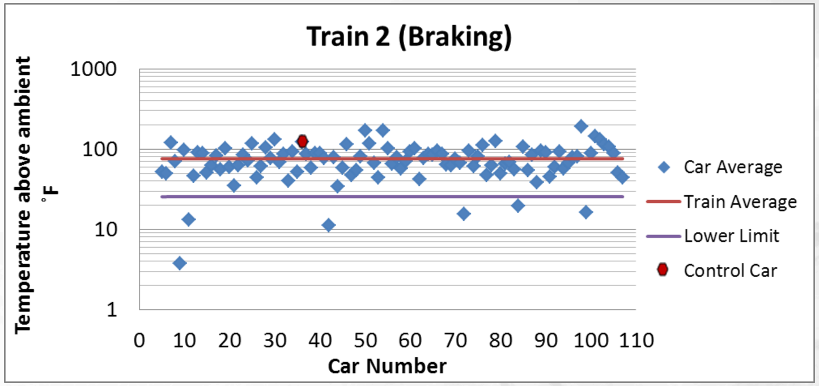


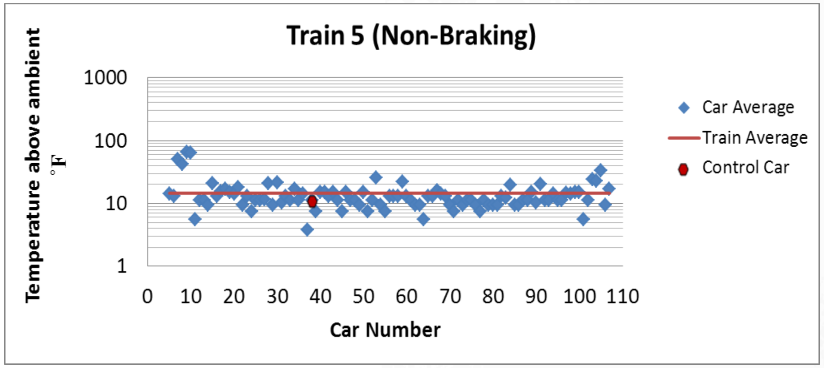
Results

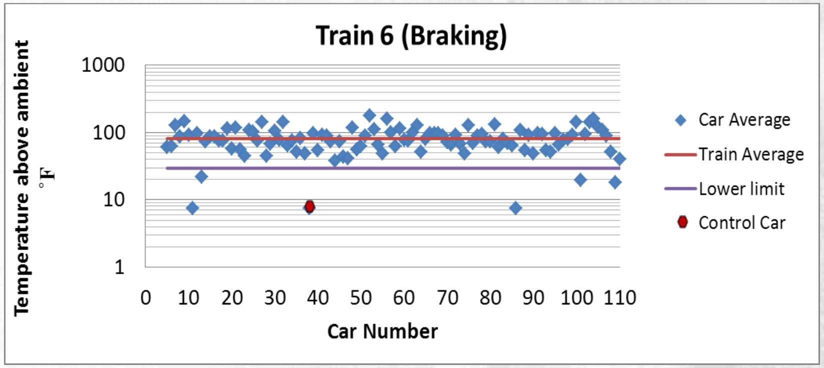
Controlled Fully Loaded Train Testing at FAST

It is also possible to make this distinction for unknown braking conditions





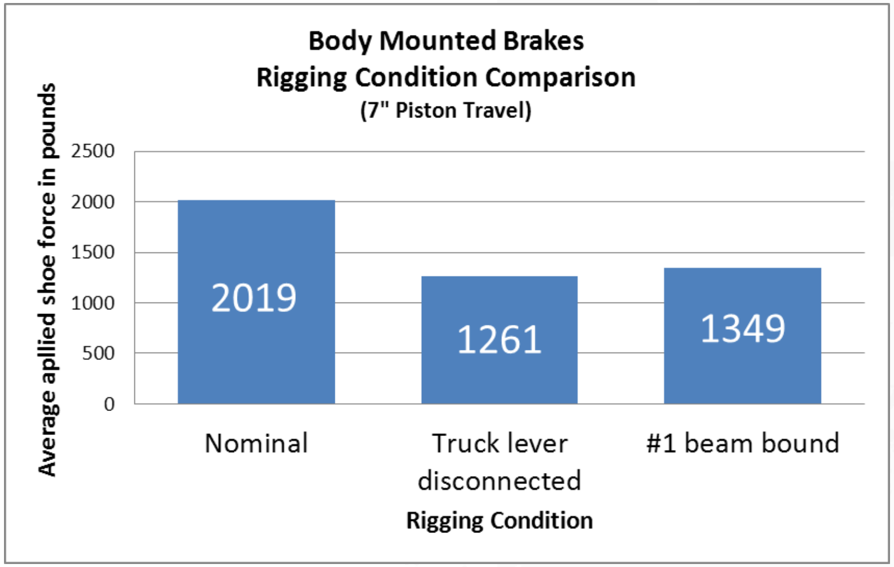


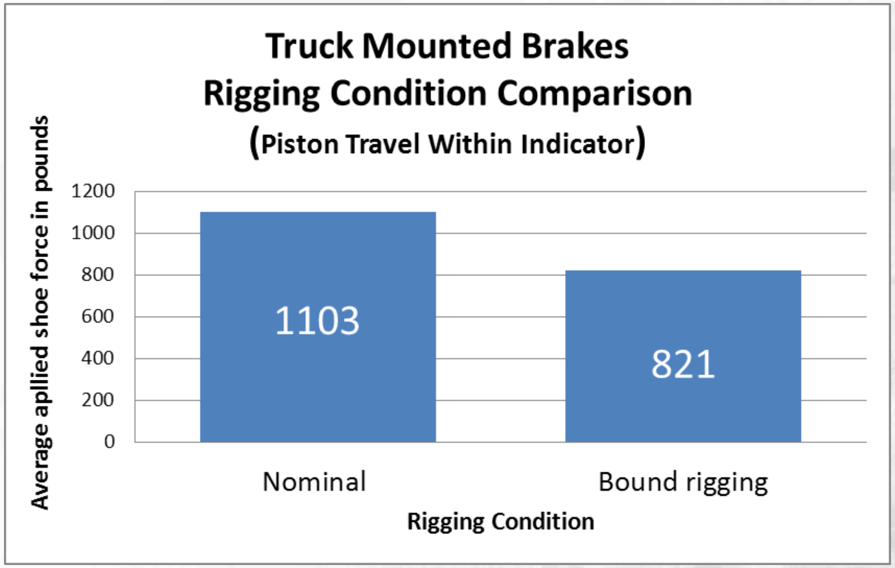


Results

Investigating Piston Travel vs. Shoe Force

Shoe force varied 25% to 39% while piston travel remained constant





Results

Revenue Service Testing on Union Pacific Railroad

- Test period October 2010 thru September 2011
- Manual inspections at North Platte, NE and Parsons, KS
- Wheel temperature detector at Sheep Creek, WY
  - Average air brake application: 7 psi reduction
  - Average time air brakes applied ahead of detector (lead locomotive): 4.88 minutes
- Comparing Methodologies
  - Manual inspection
    - 18 brake related defects reported
    - .06 brake defects per train
  - Wheel temperature detector
    - 76 "braking performance failures" reported
    - .24 possible brake defects per train
    - Several cars with repeated "braking performance failures"
    - Only one "braking performance failure" subsequently found by manual inspection

Benefits & Disadvantages

Benefits

- Objective and repeatable inspections
- Test brake system under dynamic conditions
- Truer indication of brake cylinder hold time

Disadvantages

- No visual confirmation of rigging condition

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Lessons Learned

- Testing suggests that technology can distinguish between applied (operative) and non-applied (inoperative) brakes
- Due to differences in equipment, environment, operating conditions, etc. an absolute threshold may not be optimum
- More investigation of dynamic effect on brake valve operation is recommended

Key Success Factors

- Testing indicates Wheel Temperature Detector Technology is capable of determining brake effectiveness
- Test results indicate differences in dynamic and static brake system operation
- Testing shows that proper piston travel does not guarantee adequate brake shoe force
- Final report submitted

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Machine Vision Based Inspection Systems Evaluation & Implementation

U.S. Department of Transportation
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Acknowledgements & Stakeholders

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- Norfolk Southern
- Canadian Pacific

Stakeholders & Project Partners

- Transportation Technology Center, Inc. (TTCI)
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- North American Freight Railroad Companies

Objectives

- Assess the capabilities of an automated machine vision based system to inspect safety appliances on coal hopper cars while moving in train
- Determine the effectiveness of machine vision technology in meeting the inspection requirements of CFR Title 49 Part 231 (Railroad Safety Appliance Standards) as applied to coal cars
- Assist in providing consistent and objective inspection of coal car safety appliances

Efforts are being conducted in co-operation with the AAR Technology Driven Train Inspection (TDTI) Strategic Research Initiatives

Current Processes

- Current manual inspection process is subjective due to varying degrees of inspector experience and training
- Current process exposes inspectors to rail yard hazards
- Current inspections lack historic records or accessible databases

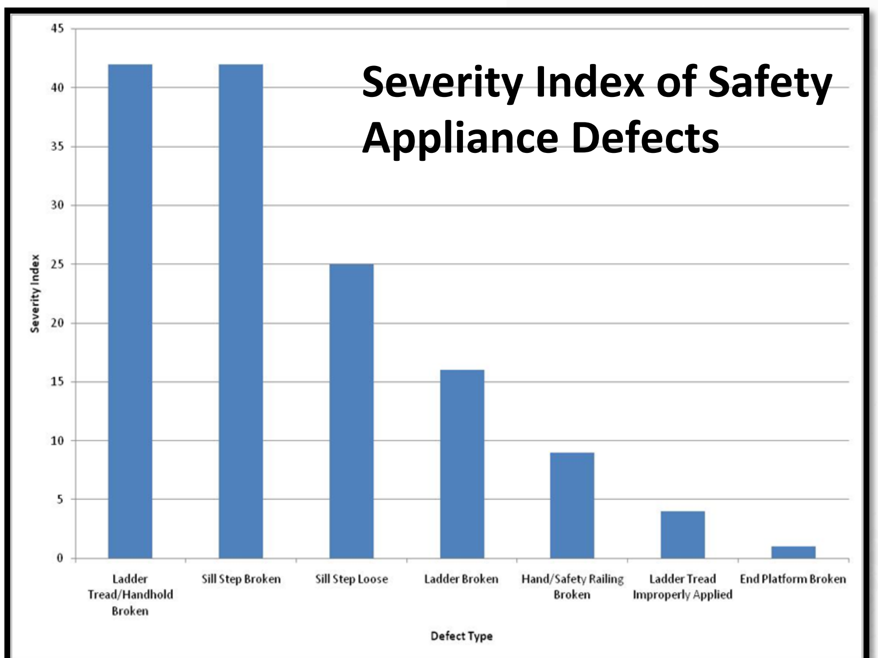
How the Technology Works

Methodology:

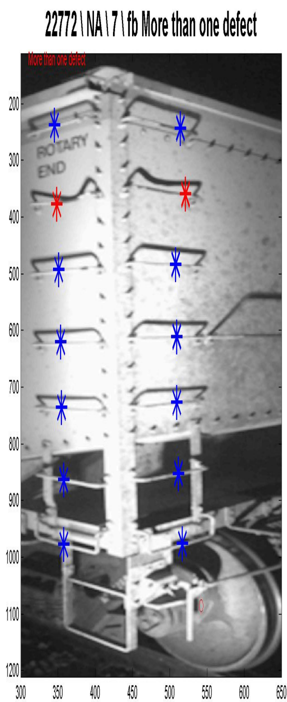
- Benchmark current inspection capabilities
- Conduct risk assessment and develop a risk assessment model to:
  - Determine frequency and consequences of various safety appliance defects
  - Prioritize safety appliance defect detection according to associated risk
- Determine methodology for assessing the technology's capabilities and effectiveness

Results

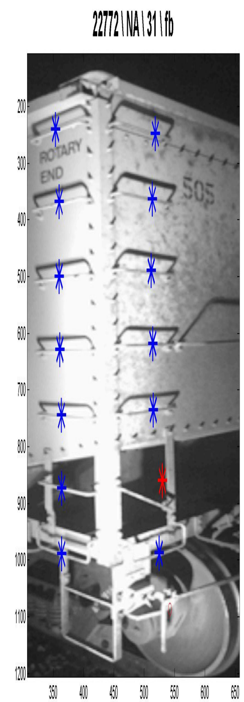
- Risk assessment completed
- Preliminary demonstration testing completed
- 96.4% successful detection rate of test defects during controlled testing at FAST



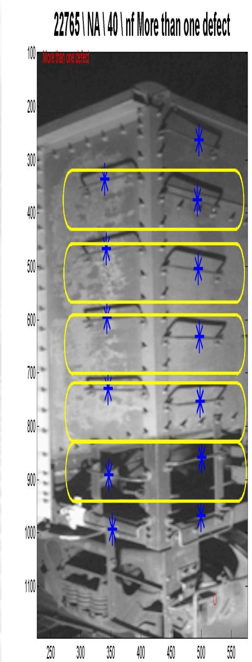
Sample test defects



Fouled hand holds



Broken hand hold



Mismatched hand holds

Benefits & Disadvantages

Benefits

- Objective and repeatable inspections
- Visual record of safety appliance condition for any given coal car
- Reduced inspector exposure to rail yard hazards

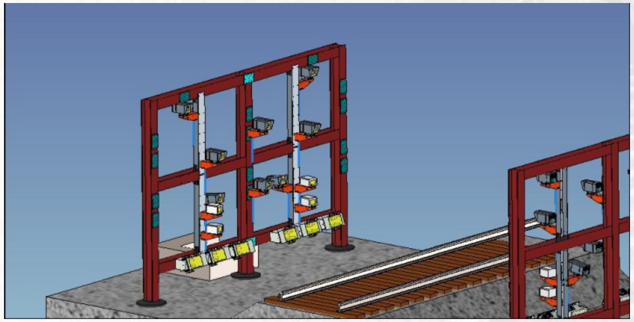
Disadvantages

- Currently unable to detect loose safety appliances
- Unacceptable false positive rate (8% to 10%)

Project Complications

Revenue service installation removed in June 2011 due to imminent flooding

- Working with vendor to replace and update revenue service installation
- Testing expected to resume in August 2012



Lessons Learned

- Need to test marginally fouled appliances (pending)
- Variations in safety appliance configurations present biggest challenge to algorithm development
- Detecting loose appliances may not be possible with current system configuration

Key Success Factors

- **Risk assessment completed and report submitted**
- **Demonstration tests show promise of technology to detect 6 of 7 top defects identified by the risk analysis**
- **Revenue service testing to begin**

Positive Project Support

Train Collision in Iowa

- This study involved a long (6,900 ft.) and heavy (19,000-ton) train moving at 20 mph, violating a signal, and colliding with a standing work train.
- The simulation study established through full-service and emergency brake applications that there was a sufficient braking distance available for the striking train to stop safely and avoid the collision under both, emergency and full service applications.
- This study was not used for evaluating any new rule or waiver. Rather, the study was conducted to ascertain that if the existing train operations and braking rules had been followed, the said collision would have been avoided.

Positive Project Support

Train Derailment in California

- This study involved the simulation of a long (7,150 ft.) and heavy (13,600-ton) train derailing in a curve.
- The train was traversing from one main line to another through sharp curve in a sag situated at the bottom of a descending grade.
- The head-end power consist was in dynamic braking mode with the remote helpers in throttle. This handling created high buff forces in the middle of train and the derailment of a lightly loaded long car coupled to a loaded short car.
- An alternate train handling simulation showed that if the head-end power consist had been in throttle and not in dynamic brake mode, the coupler forces would have been much lower, and within AAR guidelines.
- The TEDS simulations confirmed the FRA inspector's observations at the derailment site and supported his conclusions of poor train handling and train makeup as the cause of incident.

Key Success Factors

- While significant validation has been completed, a series of full scale validations will increase the level of confidence
- Appropriate training to allow users to use the capabilities of the program
- Effective user support and continued updates

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Wayside Data Analysis

U.S. Department of Transportation
Federal Railroad Administration

Program Area & Risk Matrix

Wayside Data Analysis

Program Areas / Risk Factors	Trespass	Grade Crossing	Derailment	Train Collision	All Other Safety Hazards
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Acknowledgements & Stakeholders

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- Norfolk Southern

Stakeholders & Project Partner(s)

- AAR
- Norfolk Southern
- Suppliers/Manufacturers

Description of Project

- To evaluate opportunities for risk reduction through adoption of wayside detection systems for equipment performance monitoring

- To enhance and support deployment and use of detectors to increase operational safety and reduce derailments

Objectives

- Leverage wayside technologies to:
  - Improve railroad operational safety
  - Increase safety for public at large
- Help industry improve methods of detection and inspections
- Promote performance based inspection and maintenance
- Coordinate and steer development of appropriate performance criteria consistent with FRA mission

Previous Methods

- Physical inspections
- Visual inspections
- In-field and/or shop measurements
- Concerns with the above include:
  - Human bias in interpretation
  - Measurement errors

Technology Evolution

- Automated data/performance measurement
- Proven underlying technologies
  - strain-gages, infra-red beams, lasers, etc.
- Real-time data processing
- Consistent measurement
- Customized software and applications for performance monitoring and evaluation

How the Technology Works

Wheel Impact Load Detector

- 10-13 strain-gaged cribs (rail web) between ties capture dynamic wheel load due to wheel defects
- The load level is bucketed into:
  - 65-80K (**Window Open**),
  - 80-90K (**Opportunistic Repair**),
  - 90-140K (**AAR Condemnable**), and
  - >140K (**Final Alert**)

How the Technology Works

Truck Hunting Detector

- 10-13 strain-gaged cribs (rail web) between ties capture lateral wheel load
- **OR,** laser beam detects lateral wheel position and axle angle of attack for a truck
- These measurements are converted to Hunting Index and characterized as <=0.2 (**AAR Window Open**), >0.5 **OR** 2x >0.35 (**AAR Condemnable**)

How the Technology Works

Hot/Cold Wheel Detector

- An infra-red beam used to detect wheel temperature (above ambient)
- Comparing the individual wheel to the train average provides a means to indicate if the brakes are not functioning, i.e., did not apply, (wheel is colder than the train average) OR the brakes are stuck, i.e., did not release (wheel is warmer than the train average)
- Deviation from the average used to flag the car for shop, inspection and repairs

Benefits

- Real-time performance measurement
- Consistent measurement
- Automated evaluation/flagging
- Trending to detect/predict impending "failure"
- Customized performance indices for "warning", and "alarms"

Focus of Effort

- Review and independent analysis of the data gathered from the wayside systems and its impact on operational safety
  - Statistical analysis of detector data and comparison to derailment data is underway
- Active support for the implementation of wayside technologies and evaluation of risk reduction through pilot projects

Data Analysis and Review Project Outline - 1

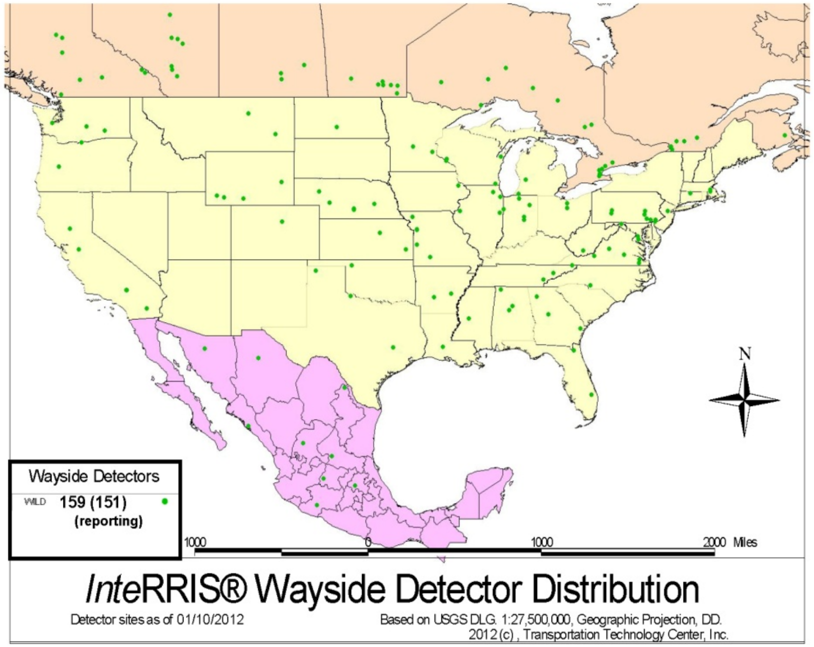
- InteRRIS® database access
- For: 130,000 pseudo ID cars
- For: WILD, TPD and THD systems
- Statistical Analysis
- Comparison to global safety data

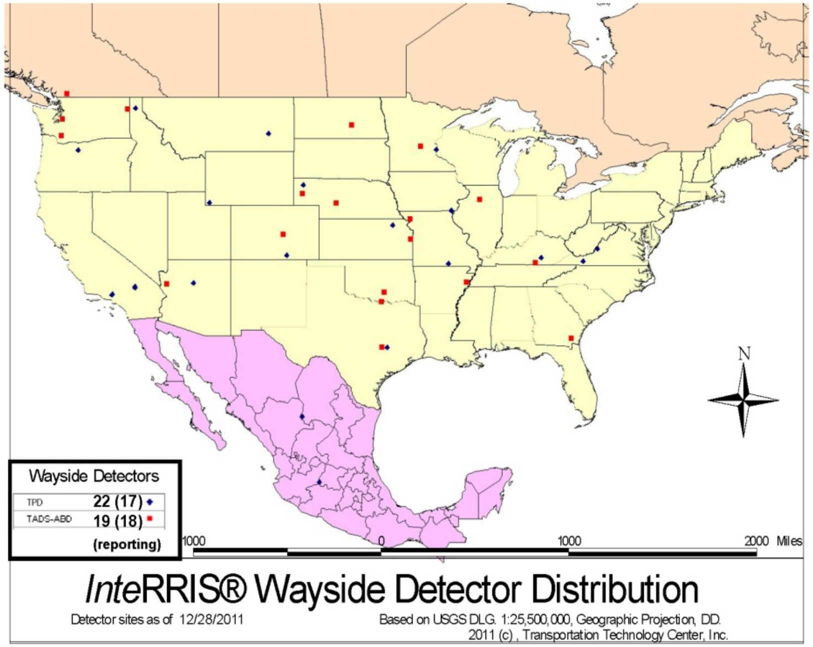
Data Analysis and Review Project Outline - 2

Pilot Project

- Test implementation: Hot/Cold Wheel Detector
- Monitor safety performance for a given period
- Compare to performance of current manual processes over the same route, time, and rolling stock
- Identify strengths and gaps of new technology
- Evaluate risk reduction

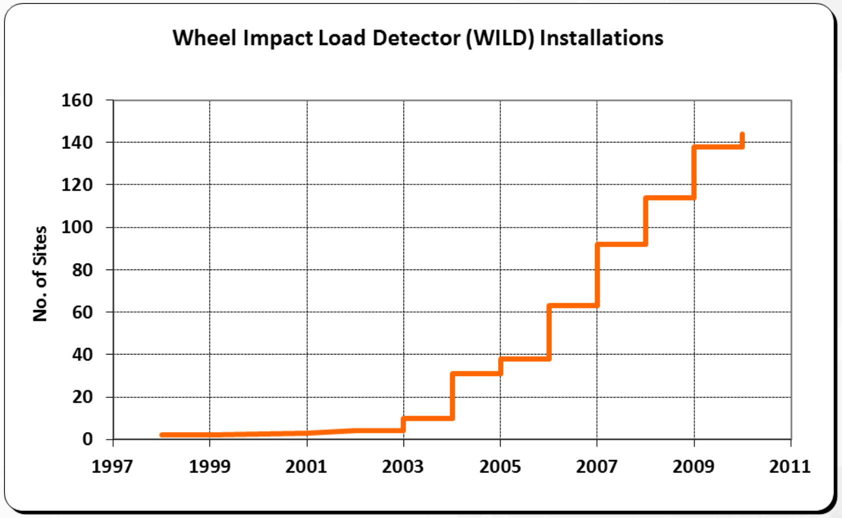
Various Detectors Deployed by the North American Railroads

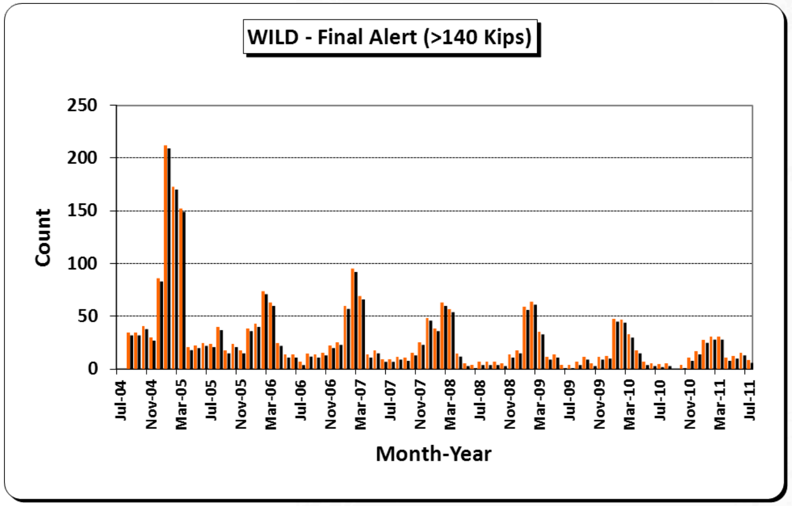


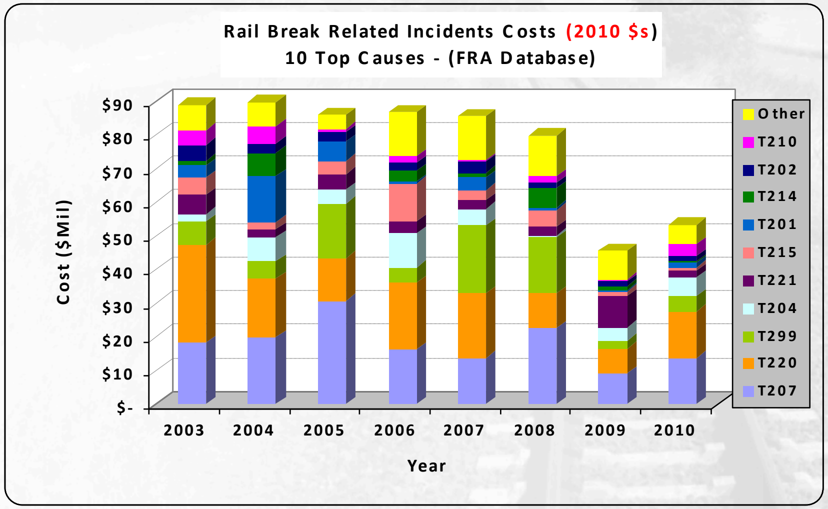


Courtesy AAR-TTCI

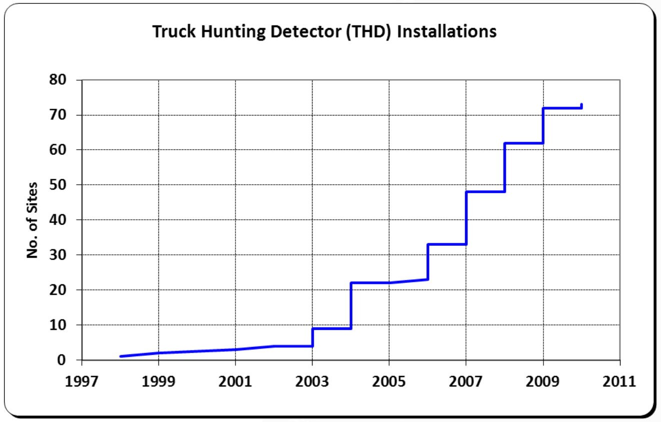
WILD Implementation

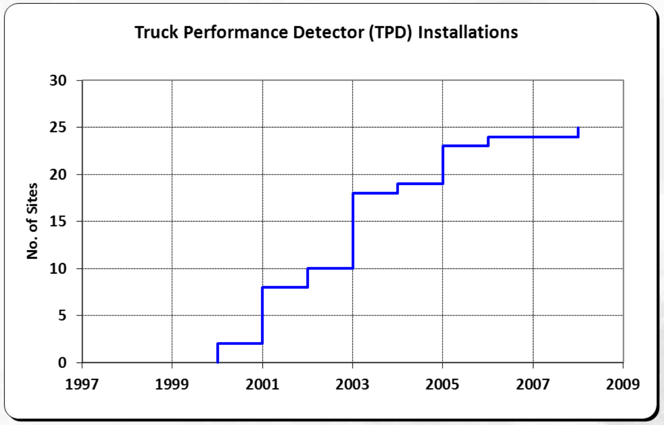


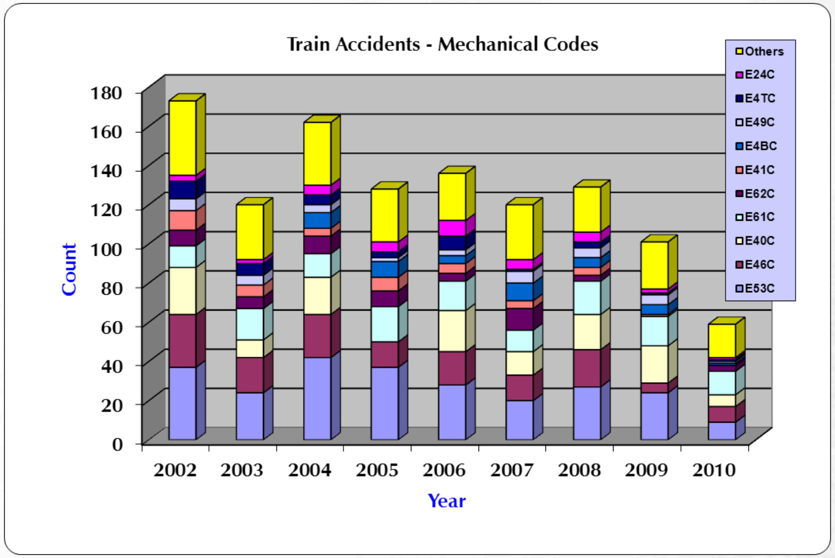




THD, TPD Deployment and Derailment Trend







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Lessons Learned

- At a global level, there is a statistical correlation between the implementation of detectors and reductions in related derailments
- Opportunities to enhance effectiveness of inspections through complementary detection methods exist
- Targeted areas of equipment and track remain to be addressed

Key Success Factors

- Access to a larger database of wayside data
- Participation by railroads in “Pilot” projects
- Successful completion of Pilot project(s) to demonstrate detectors’ effectiveness to modify/ enhance current inspection procedures

Break/Posters | Nearby Food Options (all within 5-7 minutes walking distance)

- Au Bon Pain: 601 Indiana Ave NW # 1Washington, DC 20004
- Burger King: 501 G Street NW, Washington, DC 20001
- Chipotle: 601 F Street NW, Washington, DC 20005
- Cosi: 601 Pennsylvania Ave NW # 2 Washington, DC 20004
- Dunkin Donuts: 601 F Street NW, Washington, DC 20004
- Firehook Bakery & Coffee House: 441 4th Street NW, Washington, DC 20001
- Jack's Famous Deli: 501 3rd St NW # 2, Washington, DC 20001
- Quiznos Sandwiches: 772 5th St NW, Washington, DC 20001
- Starbucks: 443 7th St. NW, Washington, DC 20004
- Subway: 501 D Street NW, Washington, DC 20001