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*Transportation Technology Center, Inc., a subsidiary of the Association of American Railroads*

# **Equipment Health Monitoring Technology Implementation: Composite Alerts**

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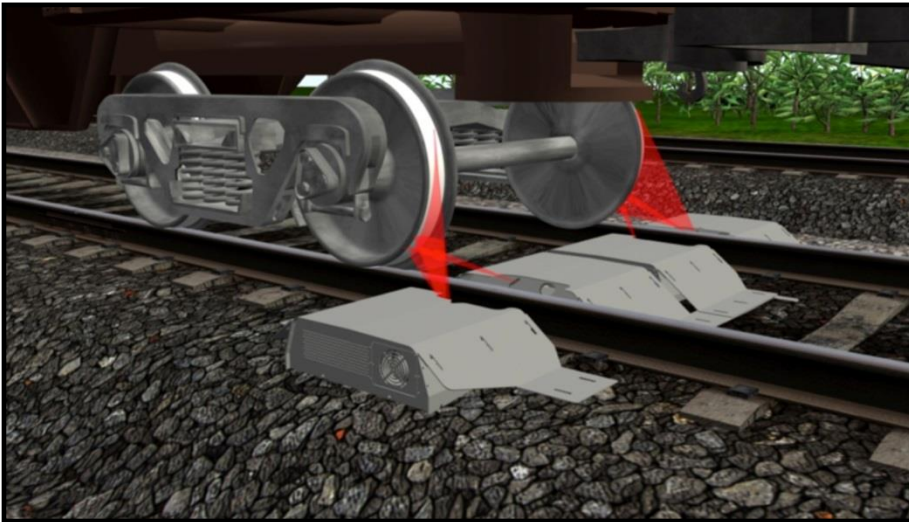
**Principal Investigator**

October 5, 2015

# Maximize Safety Prevent Derailments

## ◆ Challenges addressed by SRI 13C

- Equipment derailments
- Detector standards and detection criteria and data integrity
- Predictive maintenance to reduce train delays from unscheduled stops



End Product: Expanded use of wayside detector data with composite rules between technologies

# Equipment Health Monitoring Technology Implementation

## ◆ Problems

- Derailments
  - ▲ Broken wheels
  - ▲ Burned off journals
  - ▲ Truck hunting/Stiff trucks
- Car Repair Billing (CRB) removals
  - ▲ Thin flange removals
  - ▲ Wheel impact load detector (WILD) removals
- Manual inspection costs
- Train delay costs



# Composite Wayside Detection

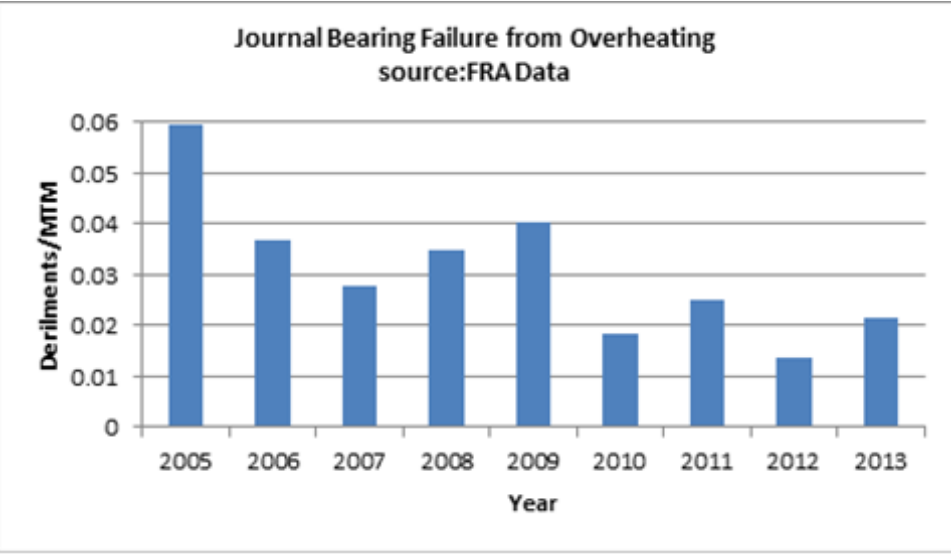
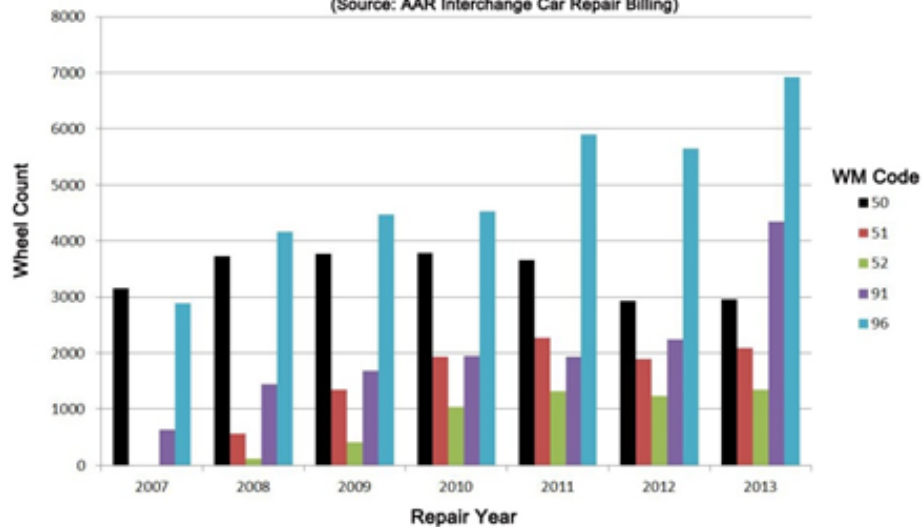
- ◆ **Composite rules have been developed using multiple detectors to permit defect identification.**
- ◆ **The following are composite AAR Interchange Rules (AAR 36.A.16-17)**
  - HBD Train — the bearing is an extreme outlier on the train and equipment (WM51)
  - ABD/HBD — the bearing is an outlier and has a prior ABD alert (WM52)
  - WILD/HBD — the bearing is an outlier and has an elevated peak WILD on the same wheel (WM52)
  - HBD and HAZMAT — the bearing is an outlier and the equipment is carrying hazardous material (WM52).





# Bearings Removed from Service

**Bearings Removed from Service  
2007 to 2013**  
(Source: AAR Interchange Car Repair Billing)



Removal Reason (WM)	Description
50	Roller bearing overheated (170 degrees F+)
51	Roller bearing hot on car and train
52	Roller bearing hot with ABD, WILD, or HAZMAT
91	Severe acoustic not verified by hand roll
96	Severe acoustic verified by hand roll

Since 2005 through 2013, the North American fleet has experienced a 66 percent reduction in derailments attributed to overheated bearings

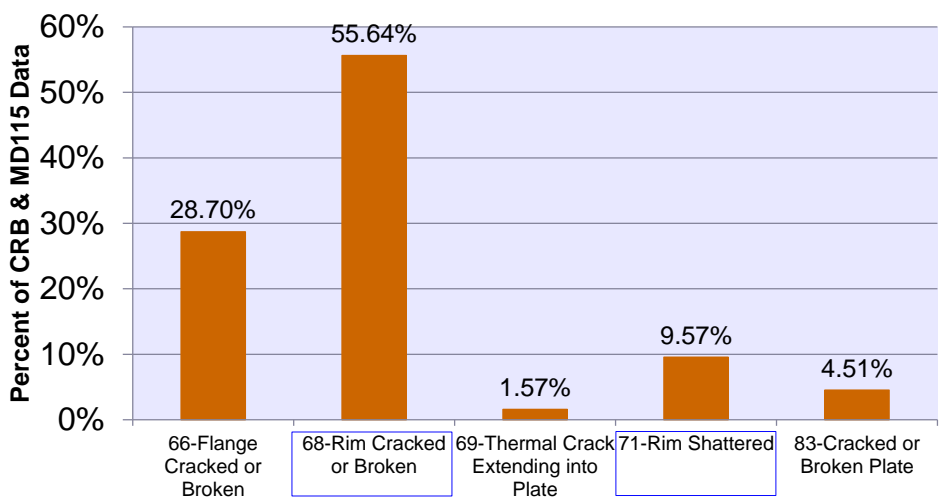


# Broken Wheel Risk from High Impact Wheels with Thin Rims

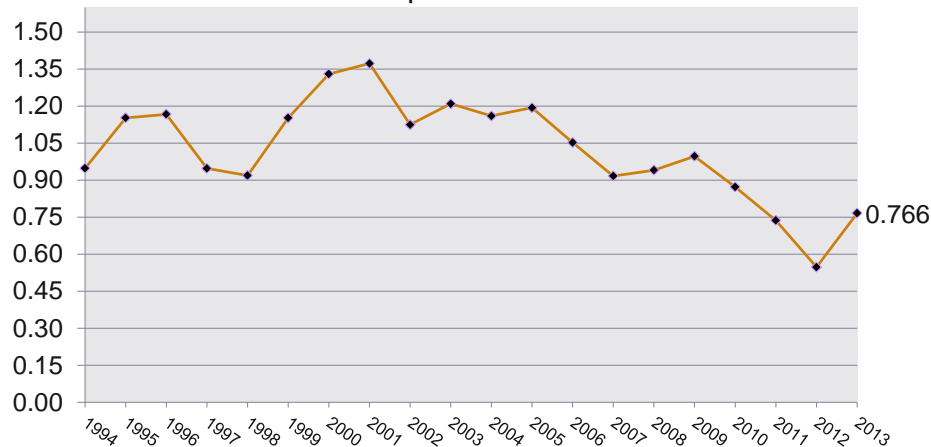
## ◆ Background

- Broken wheel derailments have one of the highest average costs per derailment of all FRA reportable categories.
- Current practices for preventing broken wheel derailments rely on inspections by carmen and removing HIWs from service.
  - ▲ Automated cracked wheel detection systems are in limited use or still under development.
- 3-years of broken and shattered rim data used from CRB and the MD-115 form, excluding duplicates.

**Reported Broken Wheel Removals**  
CRB & MD-115



**FRA Reported Wheel-Related Train Accident Rates**  
U.S. Class I Railroads on Main Track  
Accidents per Billion Car Miles





# Mechanical Repair Spending Car Repair Billing Data Exchange

## ◆ CRB Data Exchange

- Represents a portion of industry running repairs
  - ▲ Over \$1.2 billion reported in 2013

### ◆ Wheelsets (wheels, axles & bearings)

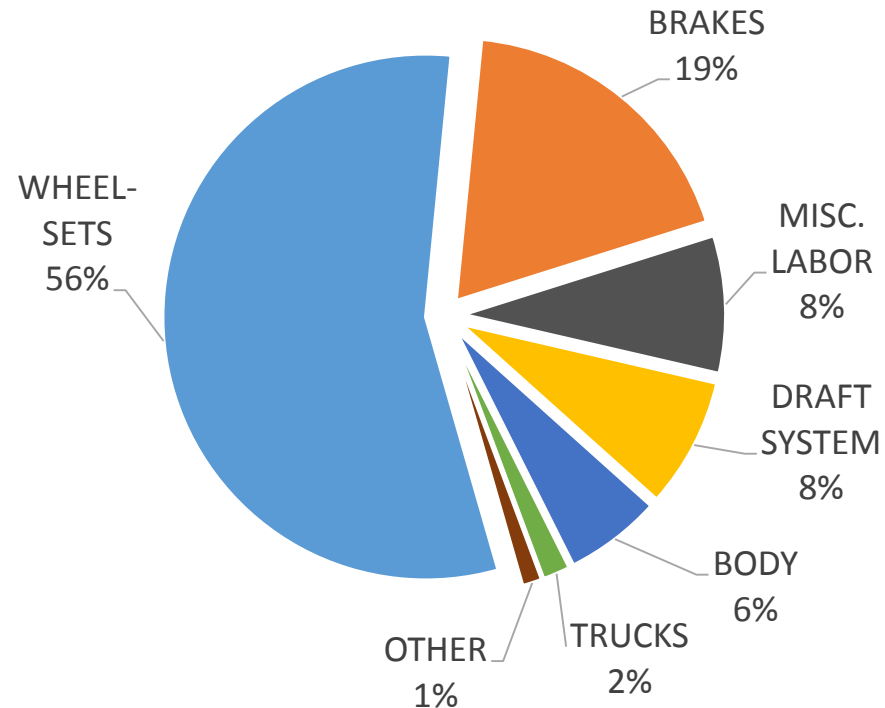
- Wheelset removals are driven primarily by tread damaged wheels

### ◆ Brakes

- Brake shoes, air brake testing, and valves comprise nearly 70 percent of brake-related cost respectively

### ◆ Body

- Securement\* parts represent over 50 percent of body-related cost



CRB Spending by Category

Source: CRB Data Exchange, 2013

\*Rule 74 SECUREMENT. (...high tensile rivets/rivets, high tensile bolts/ bolts, cotter and split key...)

# Broken Wheel Risk from High Impact Wheels with Thin Rims

## ◆ Approach

- Determine the risk of a broken wheel from its rim thickness and WILD dynamic forces.
  - ▲ About 25% of broken wheels have only empty WILD passes in the prior 30 days
  - ▲ About 12% of broken wheels have no WILD passes in the prior 30 days
- Southern and straight plate wheels are excluded in analysis

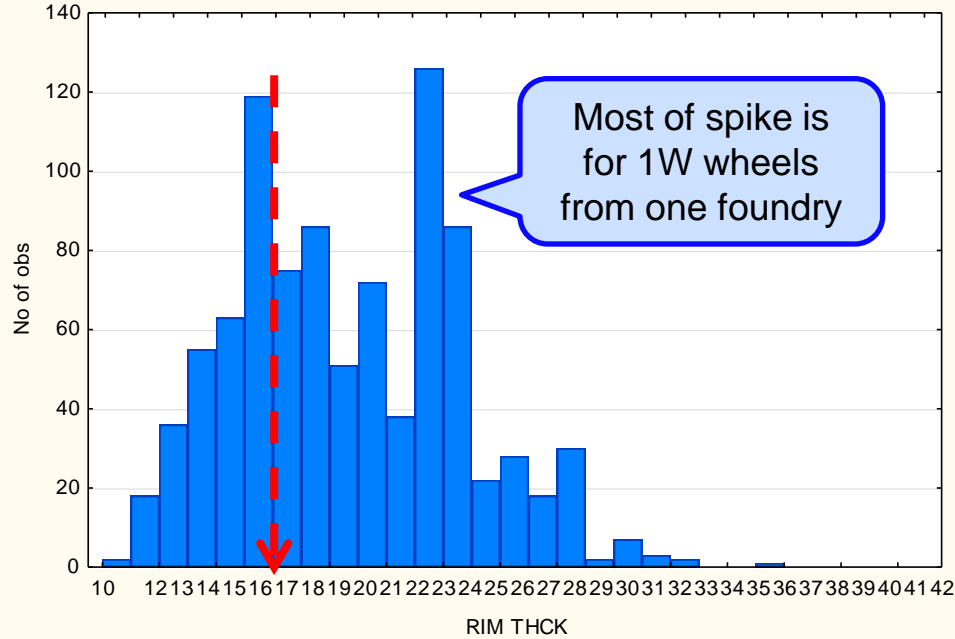




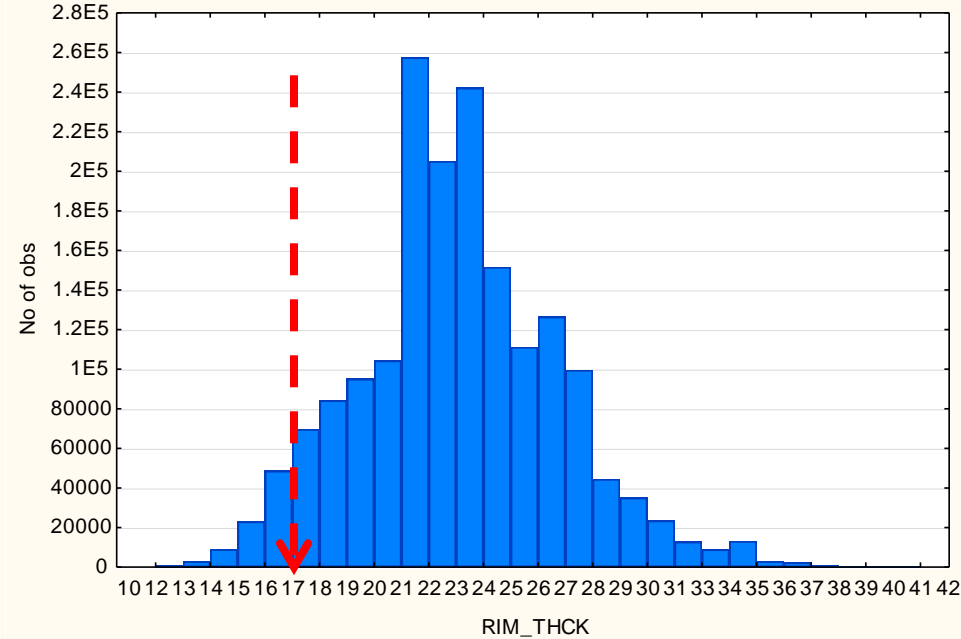


# Broken Wheel Risk from HIW with Thin Rims Rim Thickness

Histogram of Rim Thickness for Broken Wheels in CRB & MD-115 Data  
813 Wheels



Histogram of Rim Thicknesses for a Representative Population of Wheels  
1.8 million wheels (244,097 cars)



- ◆ The broken wheel data has many wheels with rim thicknesses less than 17/16th inch.
- ◆ The population has most wheel rim thicknesses between 21/16th and 24/16th inch.



# Broken Wheel Risk from HIW with Thin Rims Results

- ◆ The colors show the risk of a broken wheel relative to the representative population.
- ◆ The high risk areas could benefit from a composite rule between WILD and wheel profile thin rim detectors.

Likelihood for Wheel to Break compared to Representative Population						
Rim Thickness in 16th Inch	Dynamic Vertical Forces					
	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60
12				<b>50x or more risk</b>		
13						
14			<b>10 to 40x more risk</b>			
15						
16			<b>5 to 10x more risk</b>			
17						
18			<b>Risk like general population</b>			
19						
20			<b>Less than 1/2 the risk</b>			
21						
22						
23						
24						
25						
26						
27						

Legend
50 to 95% less risk
Risk like general population
5 to 10x more risk
10 to 40x more risk
50x or more risk



# Broken Wheel Risk from HIW with Thin Rims Detailed Distribution Analysis

- ◆ The number of wheels in the highlighted high risk group is 337 wheels. An estimate of about 2,700 wheels are at high risk in North America.
  - About 75% of the high risk wheels meet existing AAR rules for removal for WILD peak kips (AAR 41.A.1.r or 41.A.2.e) or thin rims (AAR 41.A.1.h).

Number of Wheels in the Representative Population						
Rim Thickness	Dynamic Vertical Forces					
	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60
12	598	40	20	6	6	1
13	2,497	183	105	43	30	7
14	7,493	788	349	199	93	23
15	18,754	2,528	992	494	161	63
16	38,850	6,254	2,189	865	309	98
17	55,626	9,278	2,981	1,204	432	123
18	67,627	10,912	3,596	1,366	508	163
19	76,810	12,177	3,862	1,473	493	158
20	85,309	12,598	4,138	1,536	538	149
21	91,692	13,248	4,282	1,750	618	196
22	117,323	18,321	5,870	2,563	993	375
23	163,433	27,958	8,537	3,349	1,216	417
24	198,034	31,516	8,355	2,902	919	292
25	122,747	20,282	5,635	1,980	680	220
26	85,070	18,443	5,147	1,694	574	164
27	101,473	18,484	4,551	1,365	408	133

Legend
50 to 95% less risk
Risk like general population
5 to 10x more risk
10 to 40x more risk
50x or more risk

