

IoT in the Rail Industry

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Topics

- BNSF Overview
- Sensor Applications
- Advanced, Actionable Analytics





BNSF Overview

BNSF is a Leading U.S. Railroad



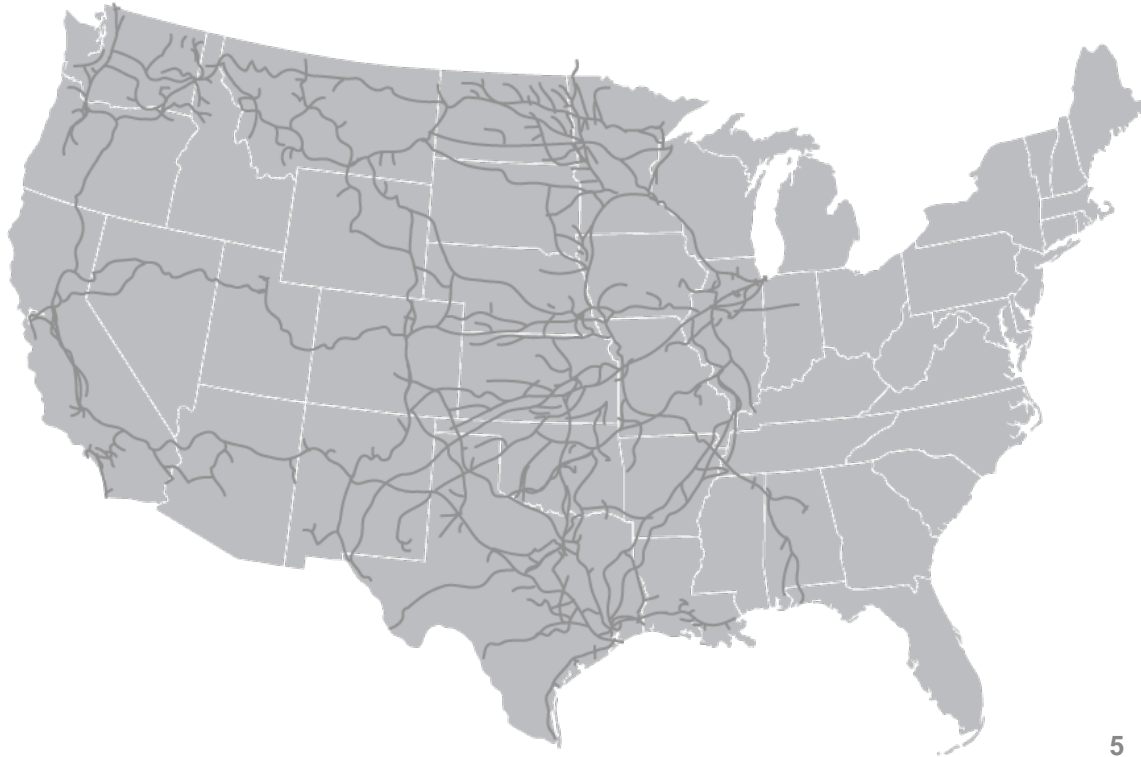
- A Berkshire Hathaway company
- **41,000** employees*
- Approximately **8,000** locomotives
- Moves **one-fourth** of the nation's rail freight
- Operates over **1,200** freight trains per day
- Leads rail industry in **technological innovation**



BNSF is a Leading U.S. Railroad



- **32,500 route miles** in 28 states and three Canadian provinces
- **13,000** bridges and **88** tunnels
- Serves **over 40 ports**



IoT at BNSF Supports Business Goals

Business Goals

Safety

Efficiency

Reliability

Assets

Track & Structure

Facilities

Control Systems

Cars & Locomotives



Sensor Applications



Locomotive Sensors For Monitoring & Control



- Internal & External Cameras
- Mechanical & Electrical System Monitoring
- Communication & Control Systems
- Predictive Maintenance

2,000 Mechanical Detectors, 30M Daily Measures

Sensors



Thermal



Acoustic



Visual



Force



Components



Bearing



Wheel



Trucks

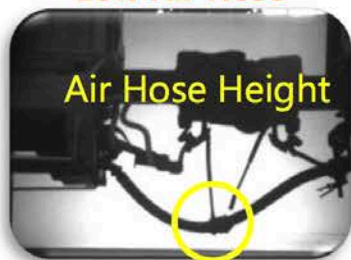


Brakes



Machine Vision Systems for Defect Identification

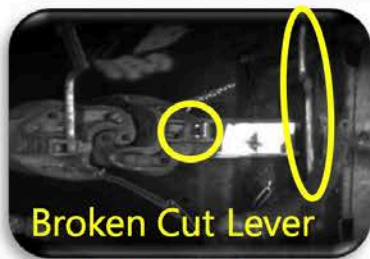
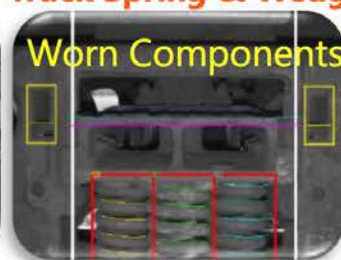
Low Air Hose



Coupler Cross Key



Truck Spring & Wedge



Undercarriage



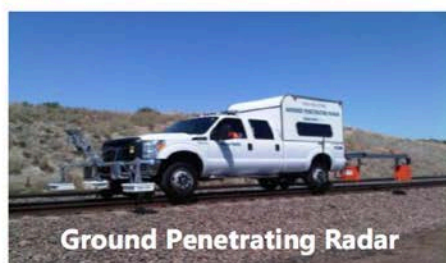
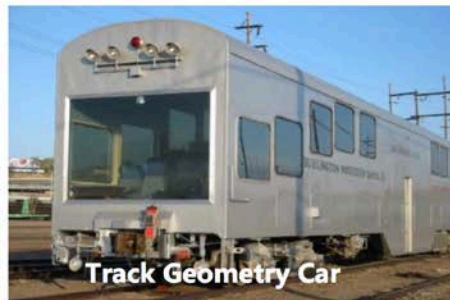
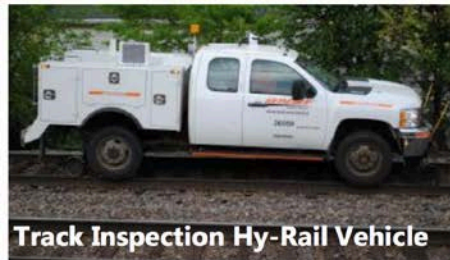
Coupler Carrier Plate



Defect identification in transit at +70 mph, 24 hours per day at 10 sites/47 modules

- **Coupler Carrier Plate & Cross Key** – Coupler securement, e.g. missing fasteners
- **Spring and Wedge** – Truck side inspection, e.g. worn truck components
- **Undercarriage** – Complete under frame inspection, e.g. structural integrity
- **Brakes** – Brake system health, e.g. worn brake shoes
- **Wheel Profile** – Wear limits, e.g. flange thickness
- **Hopper Door Lock** – Door securement, e.g. rapid discharge outlets

Advanced Technology Senses Track Condition



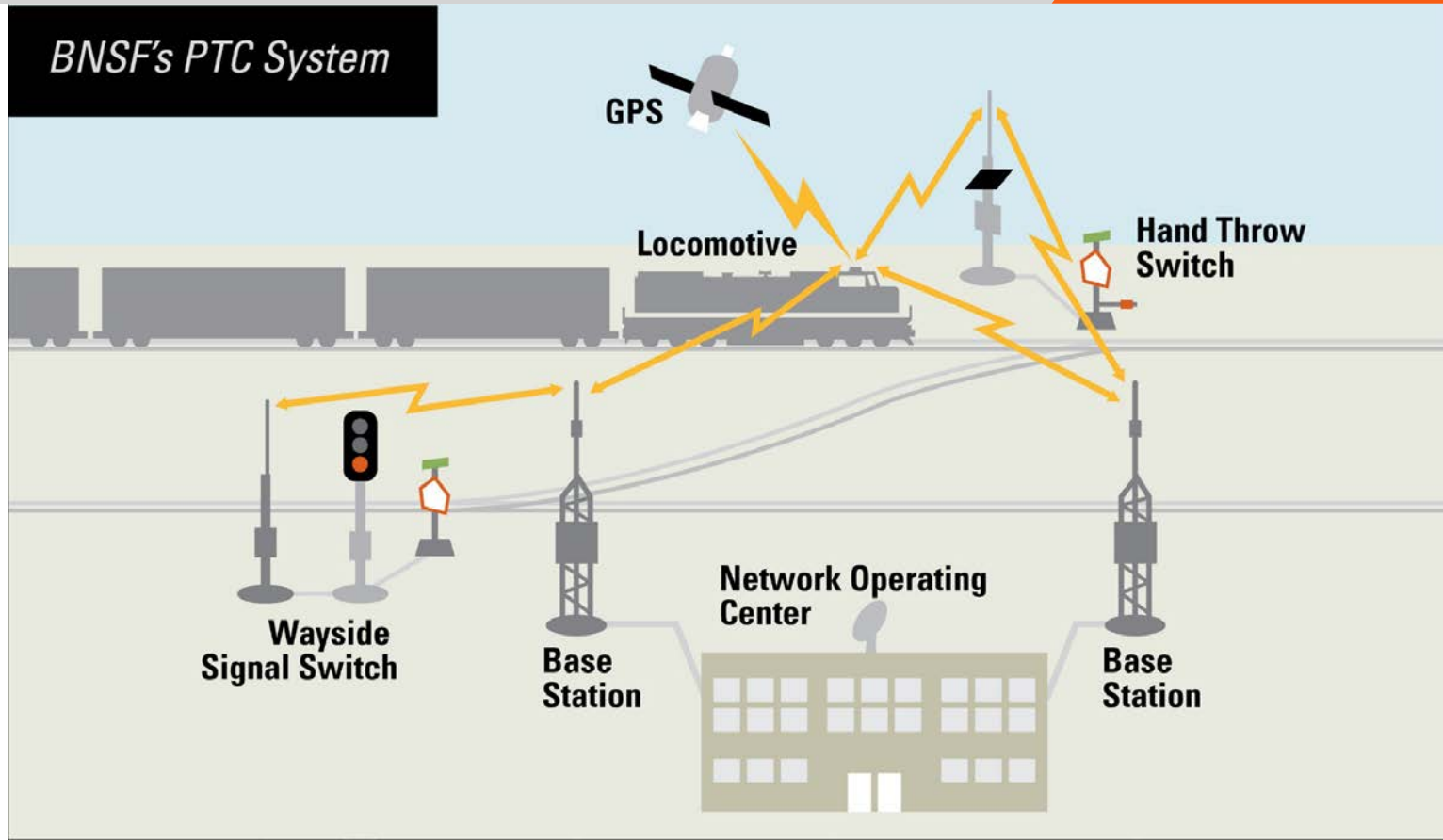
- Laser measurements
- Ultrasonic wave
- Ground penetrating radar



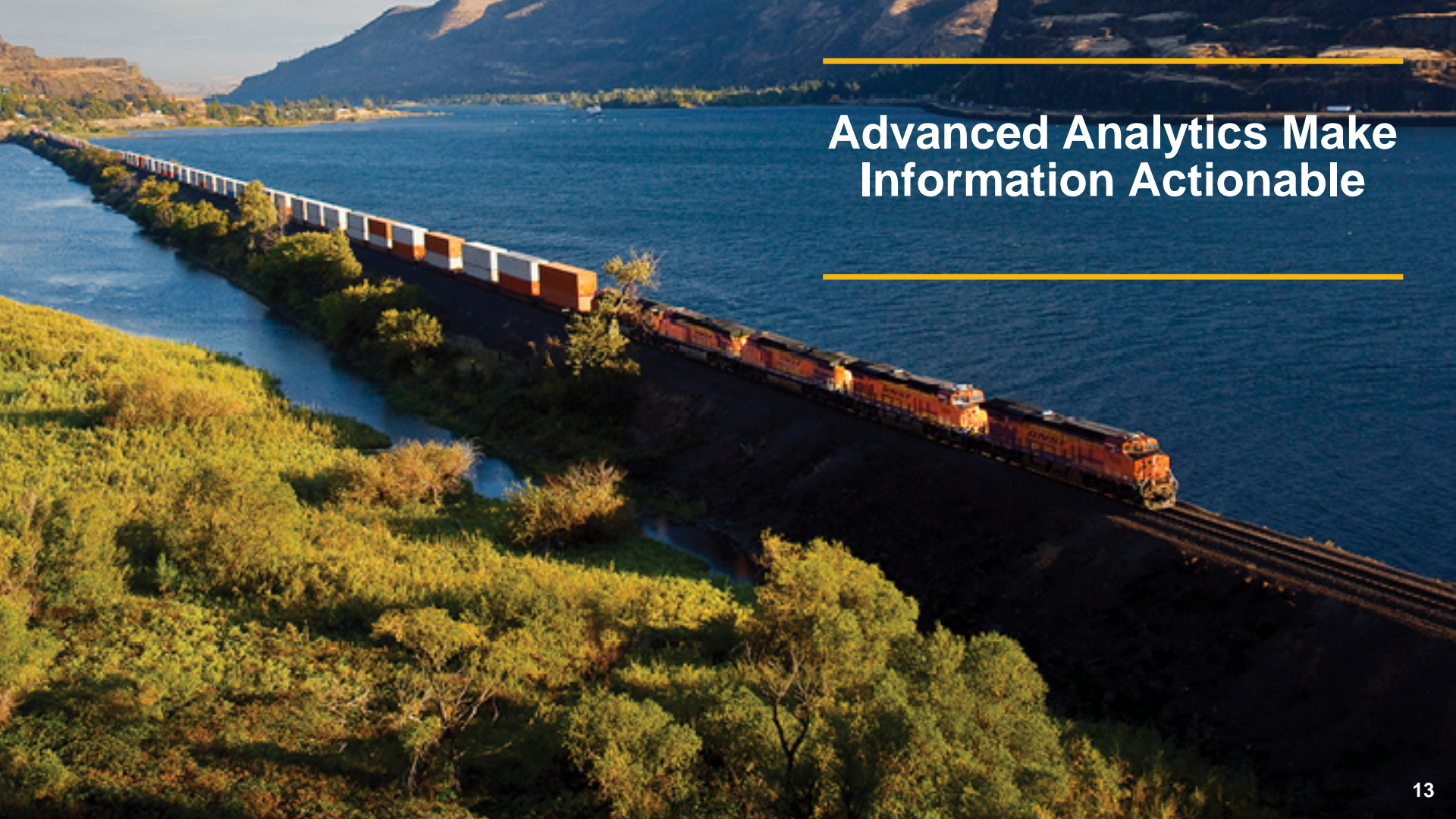
Positive Train Control for Predictive Safety

BNSF's PTC System

- Technology Overlay
- GPS, Wi-Fi, High band radio communications
- Control systems
- On-board terminal



Advanced Analytics Make Information Actionable





Predictive & Prescriptive Analytics



Detectors

Mechanical
Engineering



Analytics

Descriptive
Predictive
Prescriptive



Safety & Velocity

Condition Based
Reliability Centered

Comprehensive Applications Support Decisions

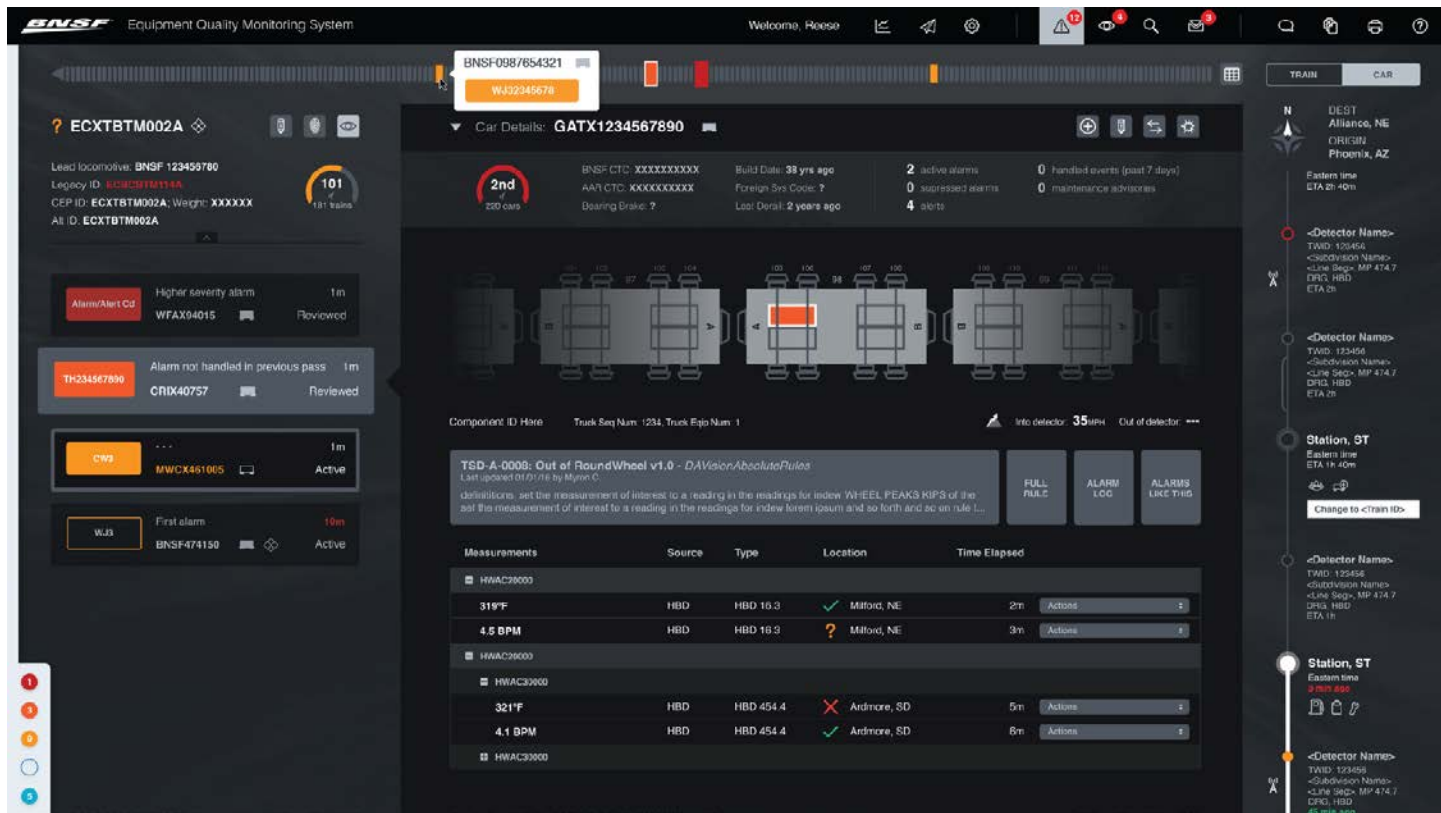
- Train Consist

- Train Tracking

- Alarm Escalation

- High Risk Components

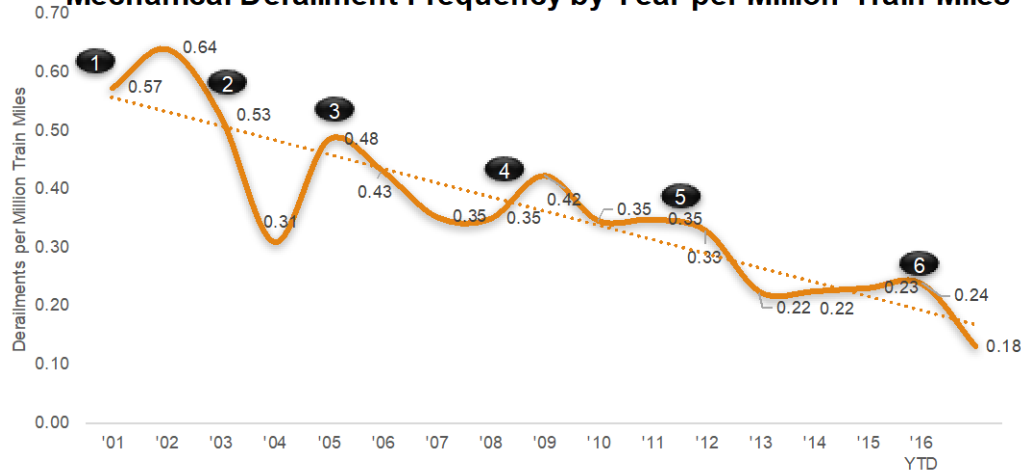
- Dispatch Communication



Detector Technology Improve Safety & Reliability



Mechanical Derailment Frequency by Year per Million Train Miles



Mechanical Derailments (2001-2016)

Mechanical ('01-'15)

Bearing related	HWD, HBD, ABD	-11%
Wheel related	WILD	-2%
Truck related	TPD	-5%

All Mechanical Derailment CAGR -5.6%

Technology / Processes

- 1 WILD and TPD Initial Installations
- 2 Warm Bearing Analysis and Acoustic Bearing Detectors
- 3 WILD increased coverage and process improvements
- 4 Cars Out of Storage Process
- 5 Machine Vision – Coupler Carrier/ Cross Key
- 6 Comprehensive Mechanical Equipment Health (CMEH)

BNSF is leveraging industrial scale IoT solutions to improve safety, reliability, and availability for its employees and customers

