IoT in the Rail Industry

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JUNE 19, 2017
• 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 Railway employees as of Dec. 31, 2016
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

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

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

BNSF’s PTC System

- GPS
- Locomotive
- Hand Throw Switch
- Wayside Signal Switch
- Base Station
- Network Operating Center
- Base Station
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 (‘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)

Mechanical Derailments (2001-2016)
BNSF is leveraging industrial scale IoT solutions to improve safety, reliability, and availability for its employees and customers.