Moving to Performance-Based Automated Track Inspection

The Benefits and Hurdles Ahead
Agenda

• BNSF System Overview
• Track Evaluation Technologies
  – Current & Future
• Information Consolidation
• Track Maintenance and Capital Replacement
• Challenges
BNSF System

- A Berkshire Hathaway company
- 32,500 route miles with operations in 28 states and 3 Canadian provinces
- 44,000 employees
- Approximately 8,000 locomotives
- 13,000 bridges and 89 tunnels
- 1,500 freight trains per day
- Serves over 40 ports
Geo Inspection Miles versus Derailments

**Geometry Car Inspection Miles & Number of Derailments**
- Main Track
- Track Caused Derailments Only
  - T001-T199, excl. T109

All Railbound Geo Car Inspections
- Gage, Alignment & Surface Defects
  - Increased inspections/data have allowed Capital Planning to be more focused.....
  - eliminate the squeaky wheel!
Track Evaluation Technologies

Sensor based with Evaluation Software
BNSF Geometry Car Systems

- 3 Manned Geometry Cars
- 3 Unmanned Geometry Cars
- 4 Hyrail Geometry Trucks
- 61 Locomotives with Vehicle Track Interaction (VTI)
Manned/Unmanned Geometry

Truck Mounted Geometry & Rail Profile Beam

Multiple display screens for Field evaluation as information is collect and analyzed

Laser Illumination with Multiple Cameras

Unmanned instrumentation the same, operated as scheduled train with buffer car
Vision Evaluation Systems

Joint Bar Inspection

Track Component Inspection

Monochrome Line Scan Cameras with lighting systems

Automated Vision System

_Transform the manual inspection into Condition Evaluation;
Effective Remediation - Now or Planned_

Rail bound comprehensive optical system capable of performing near real-time detection of rules based track conditions
Vision System Expectations

Automated determination over manual identification

Process
1. Detect the Object
2. Determine exceptions based on Rules
Optical Inspection Platforms

Track Bound Systems

Drone (UAV) Aerial Systems
Drone (UAV) Aerial Operations

Supplemental method for providing specific types of inspections or asset assessments.

• Service Interruption support
• Slope and material buildup monitoring
• Distance, volume & area assessments
• Water runoff direction and flow rate determination
UAS “Go Team”

- 24/7/365 – 45 Minute Notice from Call to Readiness
  - First responder and remediation support + data services
  - Aircraft and support systems readied for corporate jet fleet
UAS Bridge Inspection

Automatic detection and notification of faults:
- Missing rivets
- Cracks in concrete
- Rust bleeding
- Excessive corrosion / pitting
- Cracks in steel

Automatic pixel-level change detection:
- Change in rust bleeding pattern
- Change or deformation of structural components
UAS Water Flow Monitoring

Material Buildup affecting Water Flow

Dec 2017  Jun 2018  Nov 2018
UAS Measure & Profile

Birmingham Quarry point cloud from Imagery

Monitor distance between track and Quarry ledge
Light Detection and Ranging (Lidar)

System to Physically Measure, Classify Track Structure and Identify Objects

- PTC Asset Mapping
- Track Asset Management
- High-Wide Clearance
- Drainage Profiles
- Turnout Condition Assessment
- Ballast Profile
Ground Penetrating Radar (GPR)

Rail bound collection with post processing analysis for producing Ballast Fouling Index (BFI)

Two shoulder & two center antennas

Antenna Frequency determines depth evaluation
Future Technologies

In the works and need more development
Today’s Automation Development

Sensor Selection

Mechanical Engineering

Edge Computing

Cloud Processing

Machine Vision Analytics

Edge Software

Cloud Processing

Cloud Computing

Machine Vision Analytics
Comprehensive Evaluation Platforms

Vehicles that collect multiple types of condition data in a single pass

- Rail Imagery
- Tie and Ballast Imagery
- Track Video
- GPR Data
- Geometry & Rail Profile
- Lidar Data
- Machine Vision Identification
What's next

• Autonomous Measurement technology
  – New types of Lidar and Cameras from Automotive Industry
• Locomotive technology expansion
  – Full Geometry, Vision, etc.
• Sensors; Multiple types of Radar, Cameras that capture information beyond visible light
• Space born imagery and sensor data
Challenges

Current & Future
Data Alignment

Increasing the value of a single data source by aligning with others to provide better insight to track conditions.
The Challenges

• What problem is one trying to solve; Use Case?
  – What technology will provide insight to the problem
  – Not always about new data but solving with what data one has!
• Data movement & management
  – What needs to be kept for analysis?
  – Resolution of imagery; analysis versus user view
• Aggregation & Consolidation of Data for extracting additional Value
  – Data is siloed in multiple repositories in many places
• Change management to educate affected users who can best utilize
Track Condition Data Aggregation

Planning/Monitoring Systems
Comprehensive Surfacing Plan (CSP)

Current State:
- Answers the question of “where should I surface?” for division capital surfacing work
- Machine Learned process that incorporates geometry parameters with curve geometry then linkage rules
- Displayed on strip charts, track charts and Tableau reports

Improvement Opportunities:
- Adoption of the new model
- Threshold driven vs. Machine learned
Comprehensive Surfacing Plan (CSP)

- Priority (6,352 miles)
  - **Firefighter**: Reds & Oranges (20%)
  - **Reactive**: Yellows, Over elevated curves +1” (28%)
  - **Proactive**: All others (52%)

- Lists fixed assets with in limits
Future of Comprehensive Surfacing Plan (CSP)

- Solving for reporting of work locations vs CSP recommendations
  - Logical solution is from Compass on tampers
- Provides quick feedback and validation on tools

Track Chart Visualization

Strip Chart Visualization

MOW Work Order
Existing Data- Curve Model

Predicts rail wear using regression modeling:
- Rail wear from geometry car
- Tonnage (MGT)
- Degree of Curvature
- Model is not linear, accommodates acceleration of wear
Curve Model

- **Today** - Predicting Rail Wear Challenges:
  - Track Alignment
  - Rail Weight Discrepancies
  - Train model data sets
- **Development**: Implements rail wear discrepancy fixes
- **Presentation**: represent the data on Engineering track charts and Tableau reports

![Graph showing vertical head loss and tonnage (MGT)]

- 7/8” Wear Limit
- Subdivision Report
- Tonnage (MGT)
Predictive Analytics – Orange Tags

**Orange Tags** were developed to focus inspections and help prioritize surfacing behind a Geometry Car. **Orange Tags** represent track conditions that have higher priority than Yellow Tags but do not reach Red Tag limits.

**Determination Method?**
Predictive analytics are utilized with Surface Yellow Tags to predicts whether or not the Yellow Tag will turn Red in 30 days. The Surface parameters include cross level, surface and alignment with warp soon to come.

**Outside of Surface Parameters**
Gage, Cant and Rail Wear have **Orange Tag** limits established half way between Red & Yellow.
Tie Replacement Capital Program

- Tie replacement determined by auto condition assessment
- Data is analyzed, massaged, loaded into database
- Tie inspect, determines the condition bracket; good, marginal, maintenance, failed
- This data is downloaded to a handheld device for marking **2018 ~3M Ties**
- Ties are distributed via/GPS location
- BNSF tie gangs utilize app to mark ties
Tie Marking Process Improvement

Latest
- Plans audited and updated in inspection system
- Skip Intermediate marking process
Turnout Reliability

• Compiles various inspection data that speak to the condition of a turnout
• Developed scoring metric for different exceptions/data points
• Intent is to direct joint inspections (track-signal) and validate Capital mtce/replacement
• ~$40M in capital replacements each year
Future Maintenance Benefits

• Assessment with Automated Evaluation
  – Reduce field evaluation
• Defined remedial actions based on condition
• Tonnage & Environmental factors to predict degradation
• Reduce field review for Capital Planning
  – Allows Virtual Field Inspection
Affects to Work Process

• Capital Planning process change - consistency
• MOW Work process change
  – Move away from exception based repairs
  – Why do I need to fix a condition that’s not a defect?
• Define what needs to be corrected
• Providing field with clear understandable communication