

Engineering: Past, Present and Future



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CN Network



Network Track Miles

Mainline	Core	8,617
	Non-core	12,602
Non-Mainline		8,178
Total		29,397

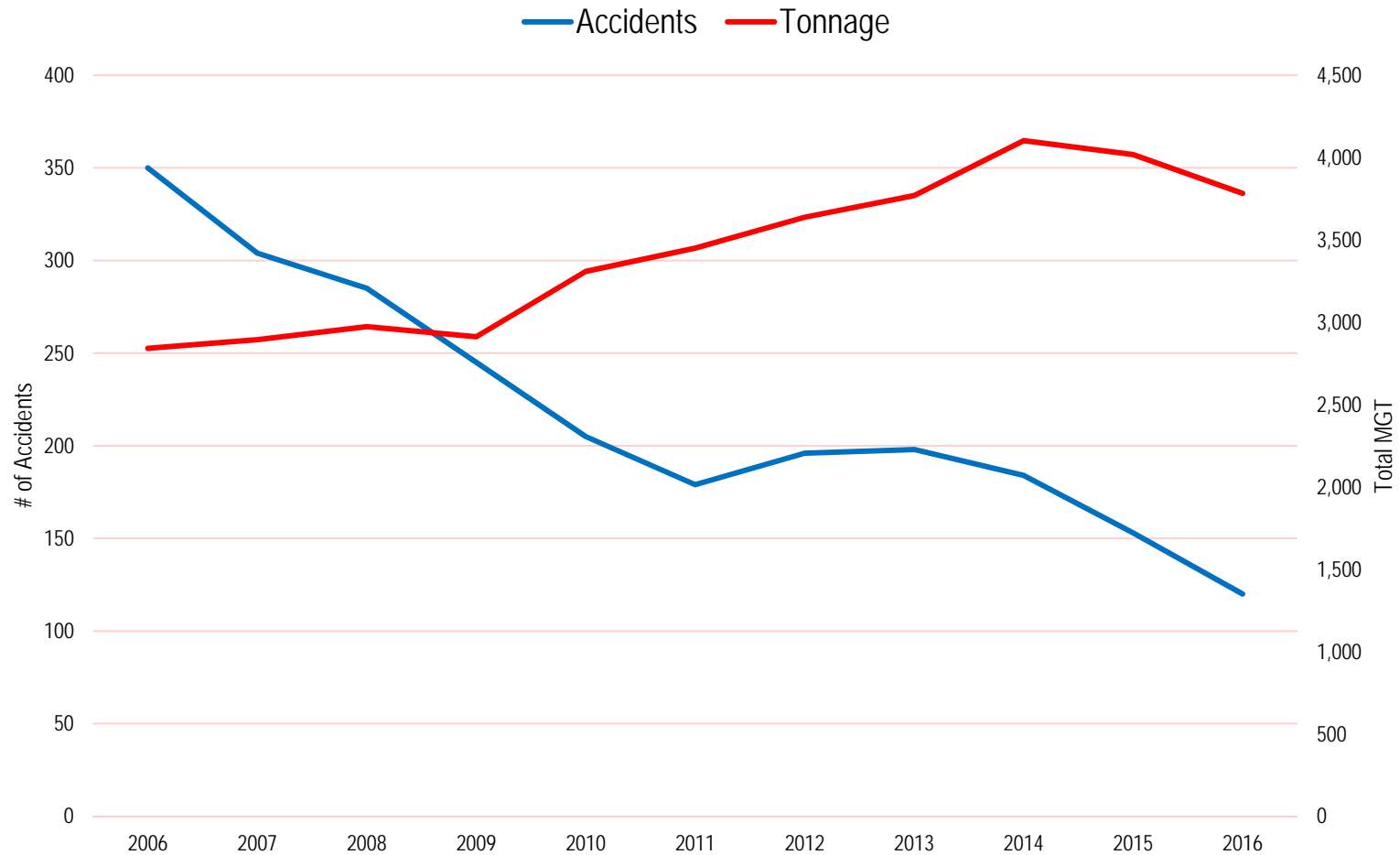
Infrastructure Capital Spending

2016	C\$1.6B
2017 Estimated	C\$1.6B

CN Engineering Safety Performance



- Engineering accidents down 65% and tonnage up 25% since 2006



My Family History



- 4th Generation Railroader
- John H. Ferryman
 - Depot Agent, GNR
 - Wenatchee, WA
- William “Henri” Ferryman
 - Superintendent Engineering, GNR
 - Seattle, WA
- William H. Ferryman Jr.
 - Chief Engineer, Denver Region, BN
 - Denver, CO



Railway Maintenance Planning



Innovation Past process

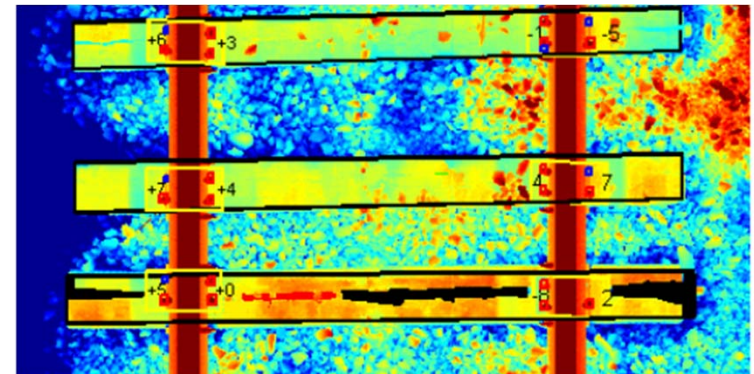
- Requests received from field employees based on their visual inspections
- Management reviewed submissions and relied heavily on subjective field

Current process Input

- Use multiple technologies collecting automated data sets
- Generate capital programs from objective data collection and risk-based scores

Future process

- Autonomous inspections
- Cognitive data streams



$$NPV = \sum_{t=1}^n \frac{R_t}{(1+k)^t} - C_0$$

Rail Maintenance & Replacement

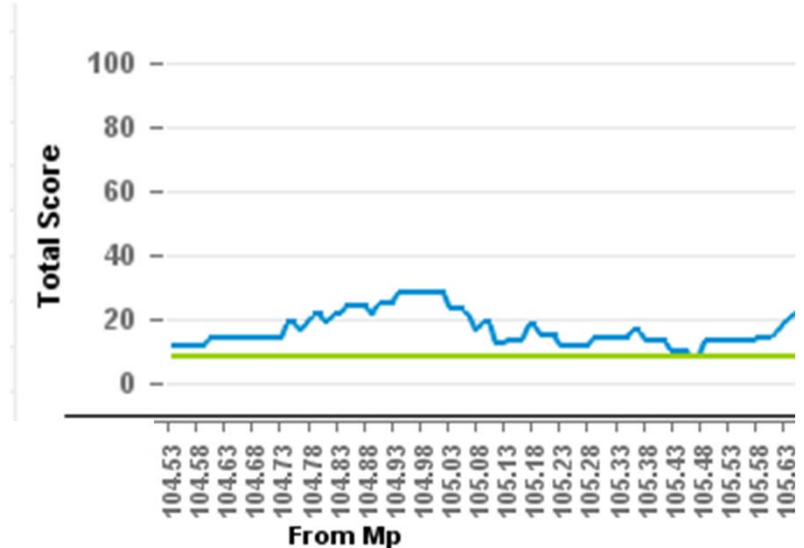


Improvements Rail Maintenance

- Created a centralized team accountable for rail grinding, rail lubrication and establishing proper curve superelevations
- Objective – optimize rail maintenance to extend rail life

Rail Replacement

- Developed a tangent rail replacement model
- The model identifies areas to relay based on a risk matrix
- Curve relay locations are based on review of historical wear rates



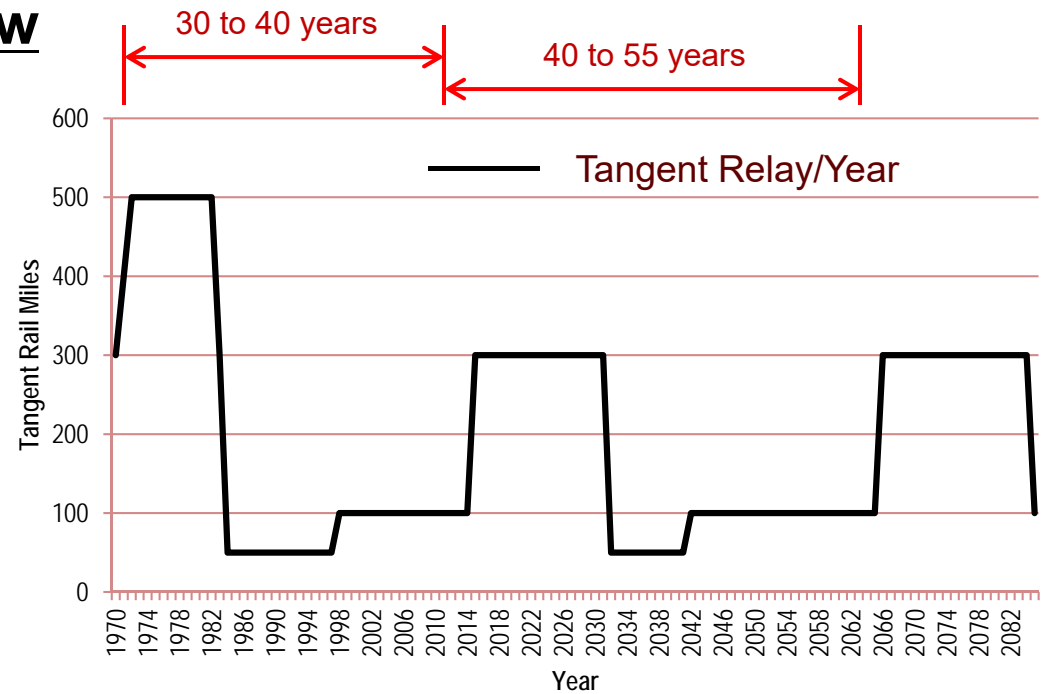
Risk Modeling of Tangent Rail



Programs

Theoretical Rail Life Review

- CN replaced a significant amount of tangent rail in the late 1970's/early 1980's
- Currently relaying portions of that rail to match the theoretical life
- As we install higher strength steel, the theoretical life will increase
- Created a tangent rail replacement model that identifies areas of higher risk using objective metrics
- The risk matrix focuses on several individual items to prioritize locations for replacement



Interdepartmental Collaboration



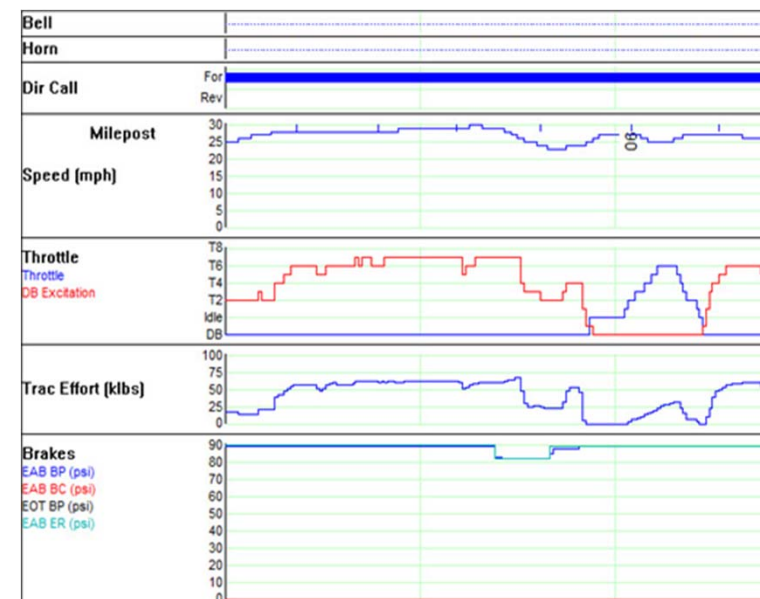
Engineering and Mechanical

- Analyzed high impact wheels (HIW) and ISRF data to better understand the correlation
- Data review led to a standard for track inspections on dark territories for specific HIW



Engineering, Mechanical and Transportation

- Operations investigation team that collaborates to find solutions to problems
- Use data and modeling to provide an objective view for challenging situations
- Objective – develop proactive strategies to reduce the potential risk of specific operations



The Future of Engineering Technology

More automated data collection

- Autonomous geometry systems
- Non-stop rail flaw testing
- VTI units
- Tie condition assessment
- Ground Penetrating Radar (GPR)
- Monitoring change run-over-run



Better utilize the information to prioritize work

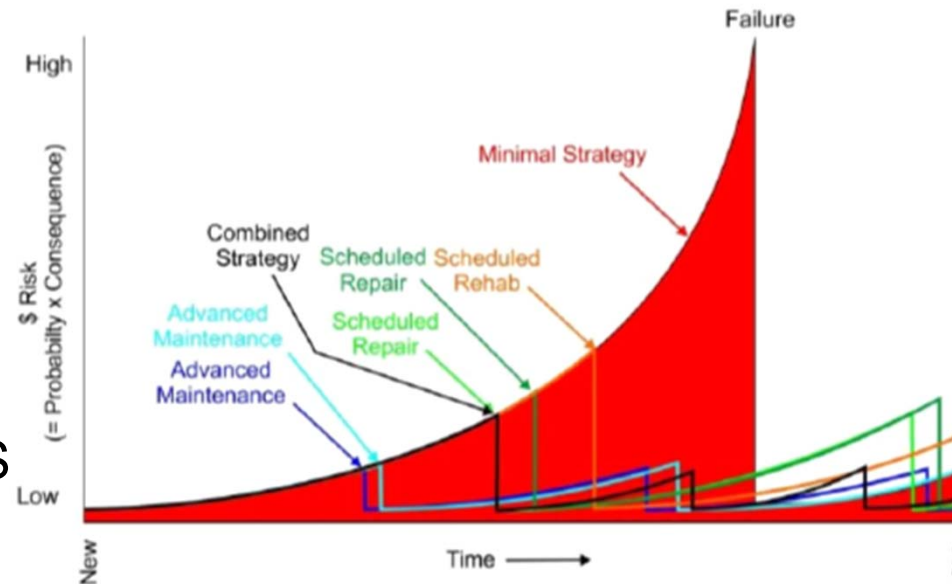
- Review data trends to develop capital and maintenance programs
- Use data to improve and optimize capital and workforce planning models
- Develop comparable and objective track health scores

Asset Management based on Life Cycles



Current Strengths

- Understanding trends for visual, RFD and Geometry exceptions
- Adjusting test frequencies and capital strategies based on trend lines
- Mapping track inventory using GIS



Opportunities

- Improve tools and reports to make it easier for field employees to access and consume relevant data
- Use multi-variable analysis to better understand track health
- Move toward a predictive/prescriptive maintenance model
- Enhance data governance and quality

Engineering Reliability Analytics



A NEW ERA ENGINEERING RELIABILITY ANALYTICS

Active Filters: Track Suprv-GTA East

Location Filters: Layers Links

Expand All / Collapse All

- Engineering Dashboard
- Productivity reports
- Cost Control reports
- Rail Reports
- Production/Zone Gang Scorecards
- Track Standards
- Procure-to-Pay (P2P)
- Inspection Compliance Scorecards
- Inspection Reports
- Inspection Vehicle Performance Reports
- Curve Superelevation Table

Conditions: Follow-Ups Inspections Critical Tasks

Rail > All

Overdue	Due	Coming Due	Not Due
0	0	1	3

SHOW MORE

SHOW ALL CONFIGURATIONS

Inspection,
Condition and
Repair
Oversight

GIS Enabled

Asset Health
Scores

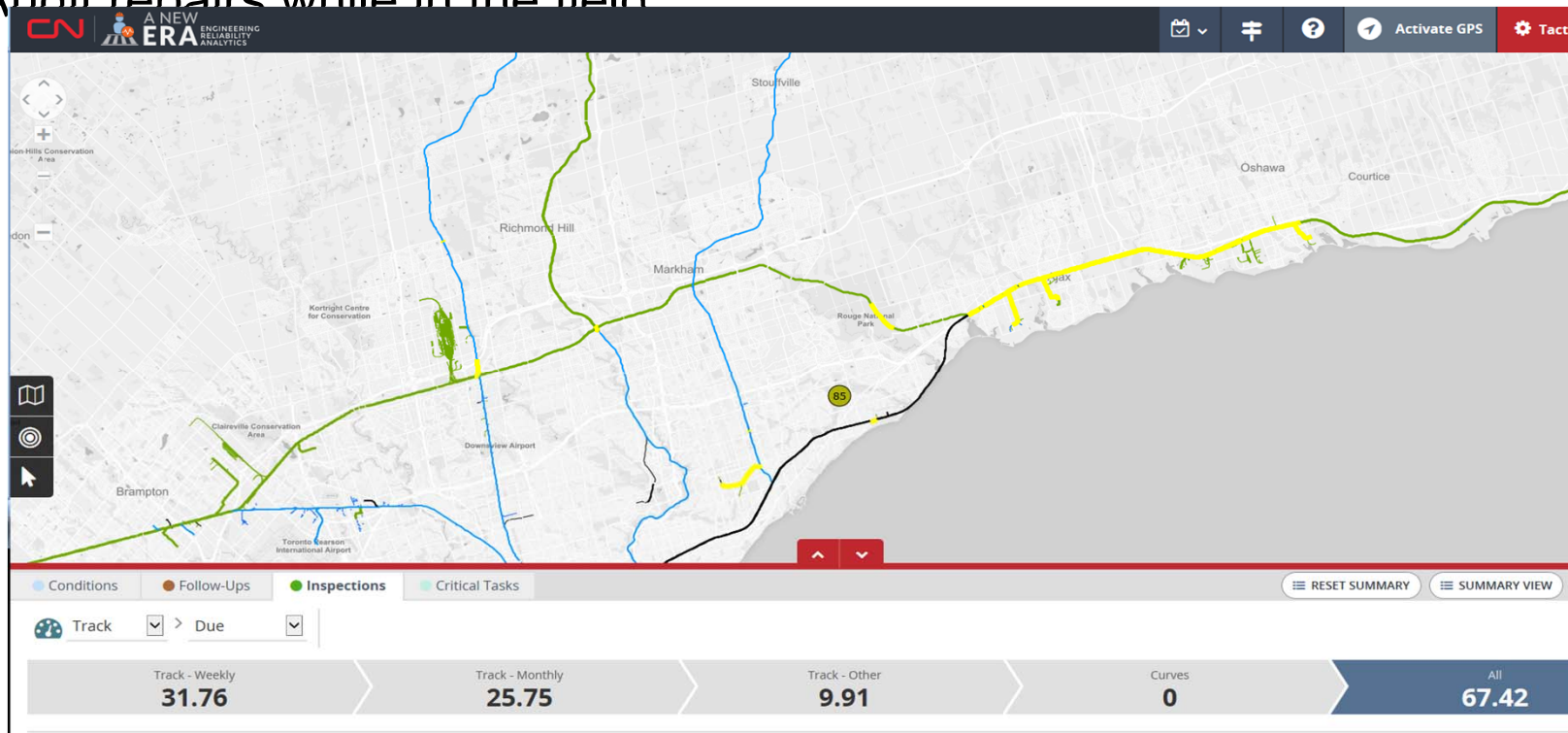
Capital
Planning Tools

ERA – Operational Module



Territory Overview and Oversight

- Quick access to territory overview
- Review inspection status
- Monitor track conditions
- Audit repairs while in the field
- Download reports and data to plan activities
- Visualize track health scores by track segment



ERA – Planning Module



Capital Planning Tools

- Reports that provide objective and comparable data
- Rail, tie and surfacing models that assist with capital planning
- Life-cycle asset management
- Foundation for predictive analytics

The screenshot displays the ERA Planning Module interface. The top navigation bar includes the CN logo, the text "A NEW ERA ENGINEERING RELIABILITY ANALYTICS", and several utility icons. The main map area shows a track alignment with a yellow-to-green color gradient. A data table is overlaid on the map, providing the following information:

GAUGE TQI	833.82
GAUGE BIMOD	0.1983
SDIV ID	664
TRACK ID	01
MILE POINT FROM	1.36
MILE POINT TO	1.59

The right-hand panel, titled "Active Filters", contains a search bar with "All Pacific" and a trash icon. Below it are tabs for "Location", "Filters", "Layers", and "Links". A link "Expand All / Collapse All" is also present. The "Layers" list includes:

- TQI-RSI
- GAUGE TQI
- LEFT ALIGNMENT TQI
- RIGHT ALIGNMENT TQI
- ALIGNMENT TQI
- LEFT SURFACE TQI
- RIGHT SURFACE TQI
- SURFACE TQI
- TOTAL TQI
- RSI
- Track Speed
- Maximum Permissible Speed

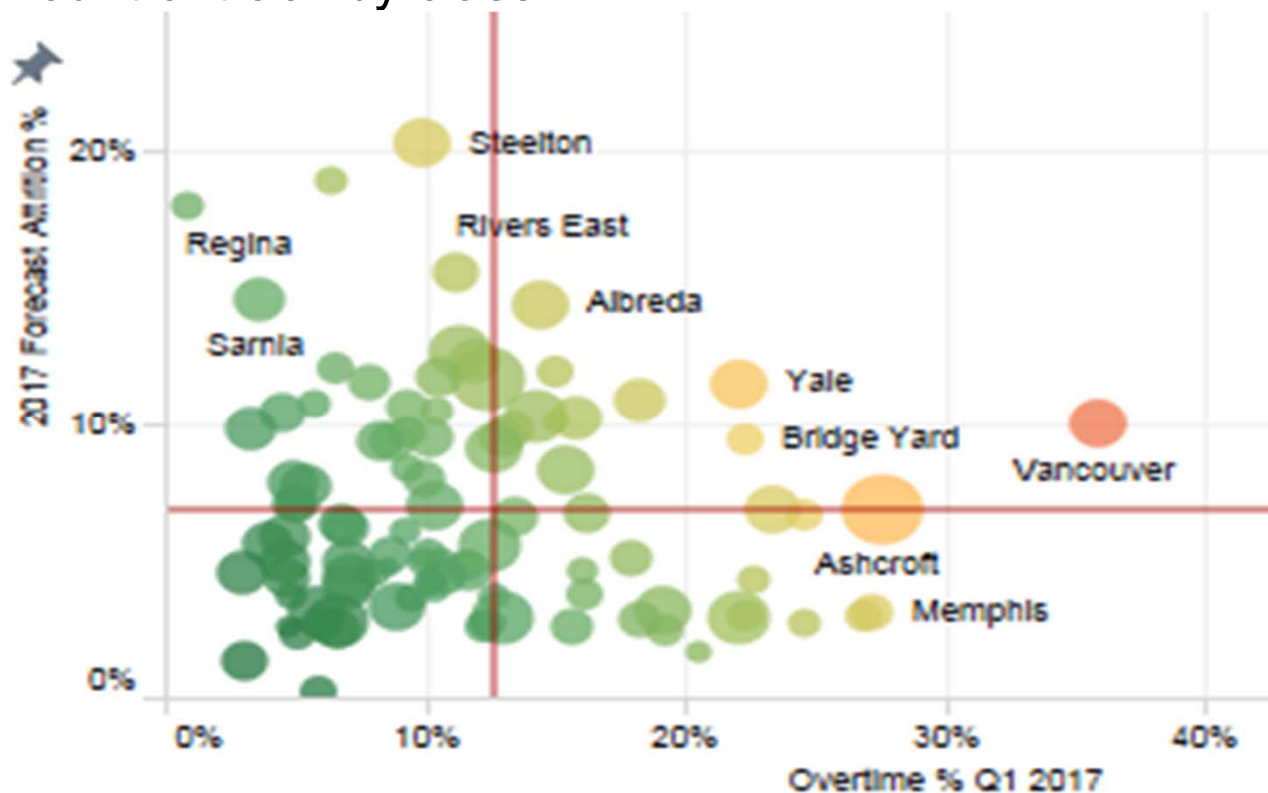
The bottom left corner of the map shows a scale bar for 500 ft and 200 m.

Workforce Planning Model



Guideline for Comparing Territories

- Point system for managing proper resource allocation
 - Tonnage
 - Amount of track by class
 - Features
 - Headcount
 - Conditions
 - Projected Traffic



Moving Toward the Future

- Developing actionable predictive models
- Establishing a scalable enterprise solution for “big data”
- Making track data easy to access and easy to understand
- Getting the data to speak to users
- Using information to lead our decision making



on

Thank You

