Monitoring and Managing W/R Interface Forces in Revenue Operation at QNS&L

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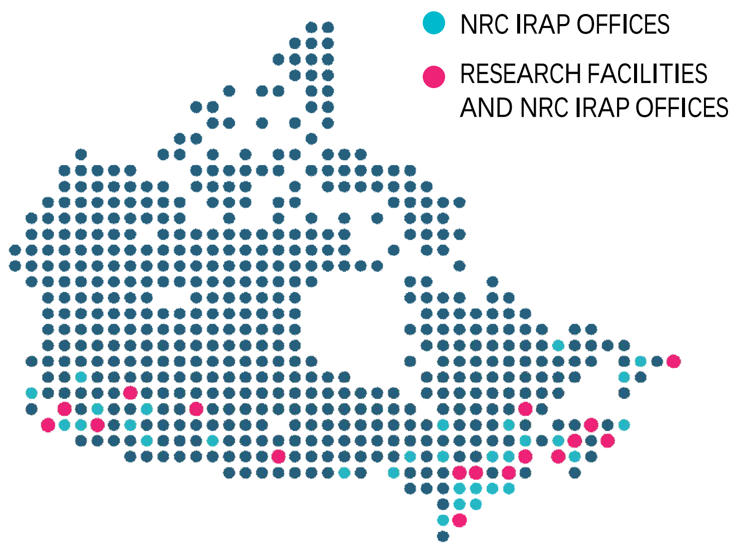
Agenda

- Introduction to NRC and QNS&L
- Why is measuring wheel/rail forces important?
- The research project
  - Goals
  - Approach
  - Challenges
  - Case studies
- Conclusions

National Research Council Canada

- We are the Government of Canada's largest research and development organization
- World renowned leader in railway research, innovation and engineering for over 50 years



Three key roles:

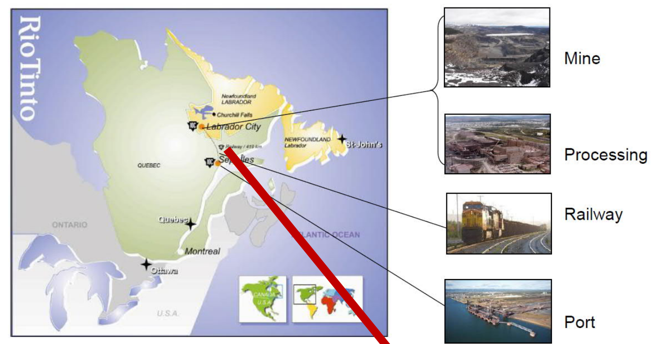
Support business innovation

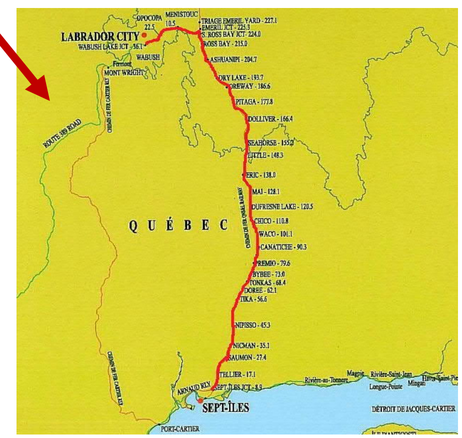
Support federal policy mandates

Advance scientific knowledge

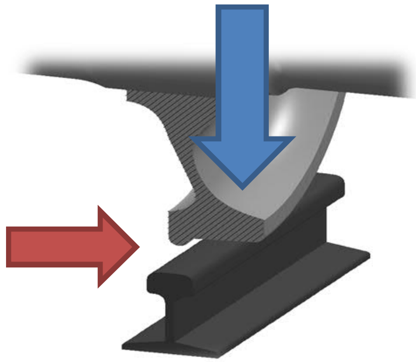
Quebec North Shore and Labrador Railway

- QNS&L is part of Rio Tinto, Iron Ore Company of Canada (IOC).
- Provides railway service between mining facilities and shipping port.
- Mountainous areas with heavy grades.
- 260 miles of track.
- No access roads
- 541 curves (45% of track).
- Up to 8 deg. curves
- 10 trains per day.
- 240 cars unit train.
- 25,200 tonnes per train.





System Deterioration/Derailment due to High Forces

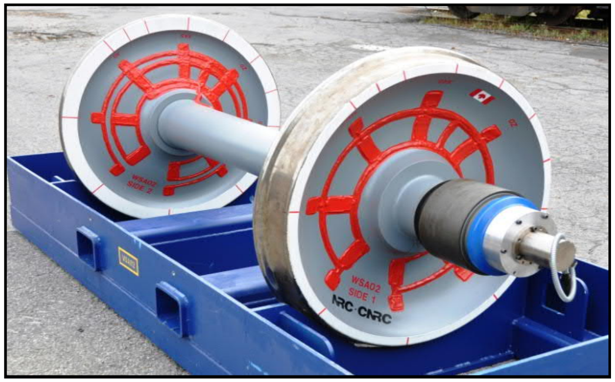


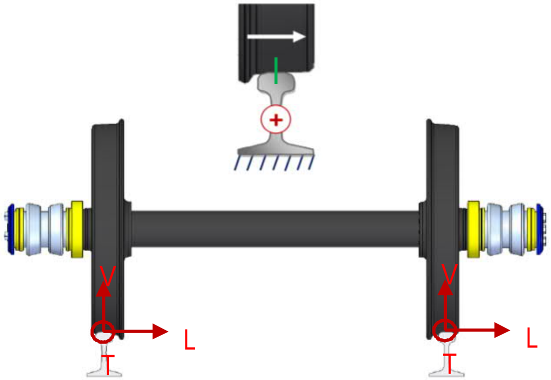
Knowing and managing wheel/rail forces is a critical factor in:

- Reducing safety risks;
- Lowering maintenance costs; and
- Maximizing service life.

Instrumented Wheelsets (IWS)

- Regular wheelset instrumented with strain gauges = dynamic (rolling) load cell
- Provides accurate measurement of wheel/rail contact forces on all three axes (vertical, lateral and longitudinal) & Contact position
- Only tool that provides direct measurement of wheel/rail contact forces along the entire track length.





Flashback...

The Use of NRC Instrumented Wheelsets In Revenue Service

(Now and in the Future)

Albert Wahba, P.Eng.
National Research Council Canada
Surface Transportation
May 9th 2012

HEAVY HAUL SEMINAR • MAY 9-10, 2012 WRI 2012 1

IWS Applications

Certification	Research	In-service Monitoring
New Railway Car / Truck Design Track Qualification	Derailments Locomotive Positioning	Continuous Track Monitoring

Currently not available

HEAVY HAUL SEMINAR • MAY 9-10, 2012 WRI 2012 9

Integrated Wheel/Rail Characterization through Advanced Monitoring and Analytics – an Overview

Antonio Cabrera – Assistant Chief Officer, Track Engineering, MTA-NYCT

Eric Magel – Principal Research Officer, National Research Council, Canada

RAIL TRANSIT SEMINAR • JUNE 5, 2017 WRI 2017

FTA Office of Research Project NY-26-7113 Wheel/Rail Characterization, Monitoring and Analytics

Eric E. Magel, National Research Council, Canada
Bruce Alexander, New York City Transit

RAIL TRANSIT SEMINAR • APRIL 30, 2018 WRI 2018

Findings from the NYCT - FTA Wheel/Rail Analytics Project

A Research Project Overview

RAIL TRANSIT SEMINAR • JUNE 18, 2019 WRI 2019

QNS&L Maintenance Challenges (Main Track Defects)

- Wide Gauge:
  - Plate Cutting
  - Premature wear on plate holes and screws
  - Wear on the plate shoulder
  - High percentage of curved track with wider gauge → running band on the wheel is offset to the field side of the tread
  - Wheel Shelling

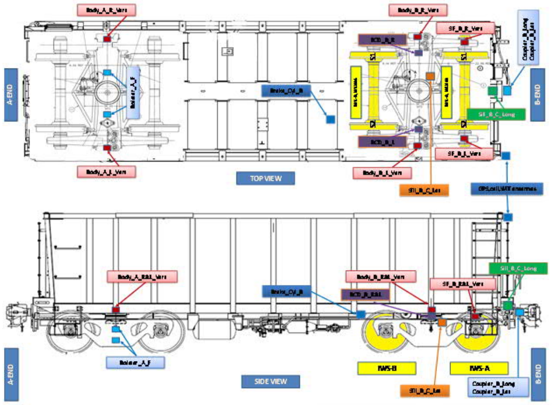



Project Goals

- How to maintain an efficient and safe railway system with limited budgets?
- How to prioritize the track maintenance plan?
- How to evaluate and demonstrate the effectiveness of maintenance activities.
- Identifying root cause of plate cutting and gauge widening problems.

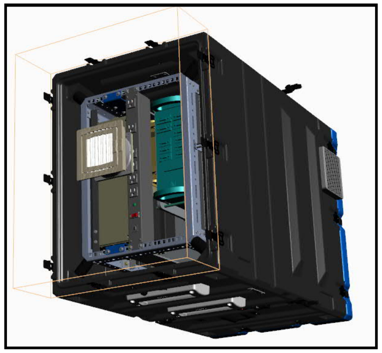
Project Approach

- Instrumented car:
  - Wheel/Rail forces using Instrumented Wheelsets;
  - In-train forces;
  - Car body vertical displacement;
  - Car body vertical, lateral and longitudinal acceleration;
  - Side frame vertical acceleration; and
  - GPS
- Continuous system performance monitoring during in-service operations for almost 1 year. 2-3 round trips per week.
- Combine Instrumented Car data with other track data (features, inspections, TG…).



Project Challenges

- Power Source
- Harsh environmental conditions and rotary dumper
- Data monitoring and transmission
- Timely processing/ analysis of large volume of data



Data Analytics Approach

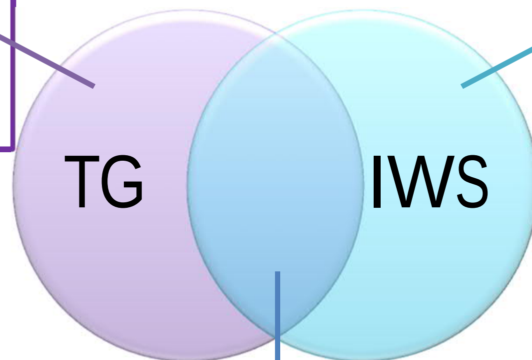
Lateral to Vertical Force Ratio (L/V)
- Identify wheel climbing and rail rollover risks.

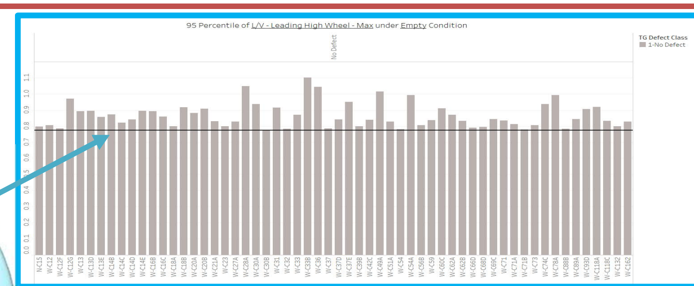
Truck side lateral force (TSLF)
- The sum of lateral forces of two wheels on one side of the same truck.
- High lateral force from leading axles is normally the main cause of wide gauge and lateral plate cutting.
- TSLF identifies situations where the trailing axle also generates a high lateral force, which indicates unfavorable truck and curve conditions.

Peak to peak vertical force (PPVF)
- High dynamic force is normally the main cause of vertical plate cutting.
- In the present study PPVF is calculated as 4.5 times the standard deviation.

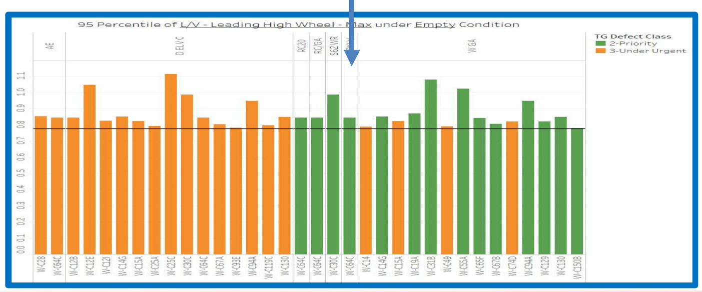
For these force parameters, no threshold values were applied. Instead, a limit based on relative comparison is used, with locations where the force level exceeds the 99th percentiles of all track locations being flagged.

Case Study: Track Geometry and IWS

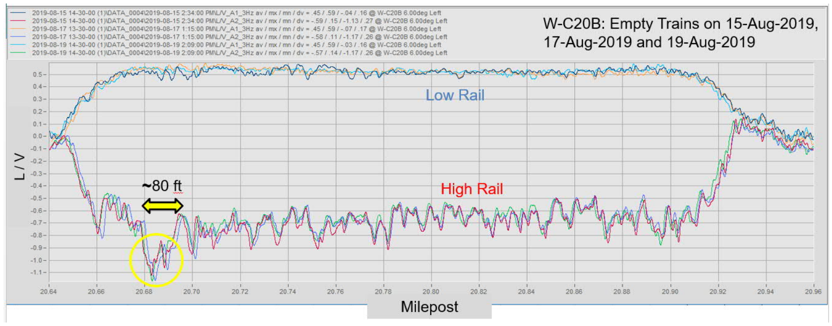


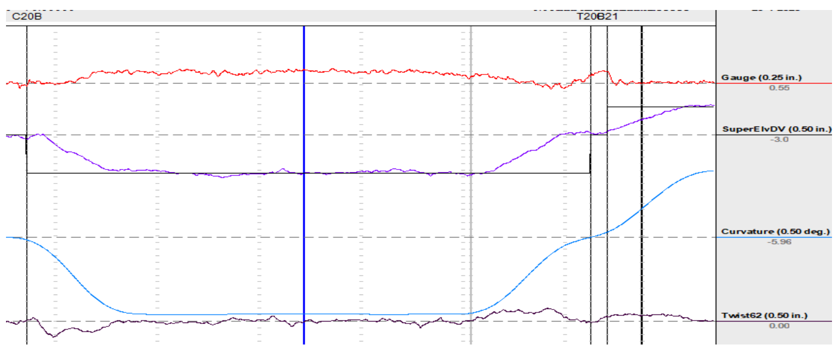


Identifying these high-force locations allowed for preventive maintenance



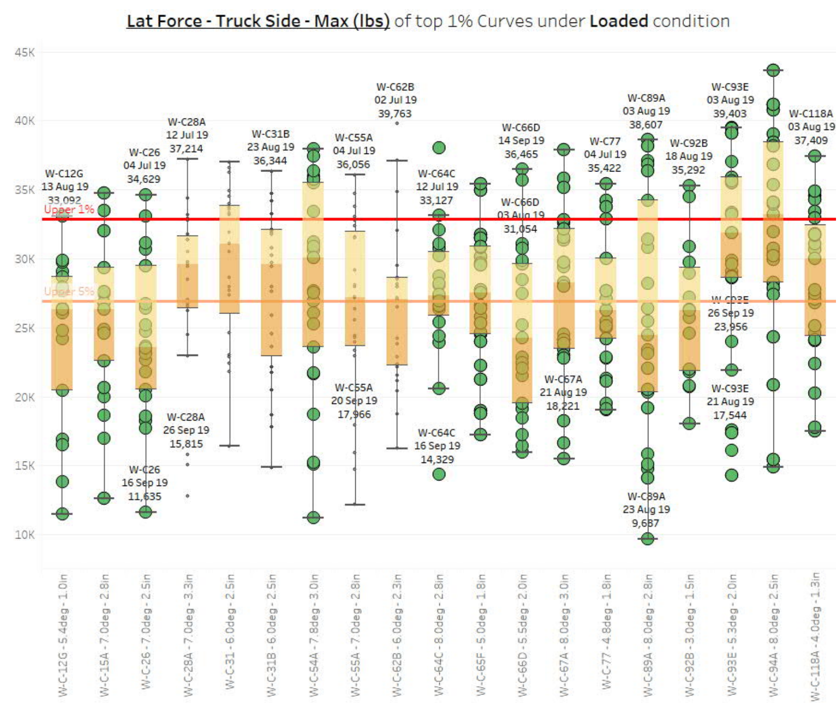
Case Study: Track Geometry and IWS (Cont.)





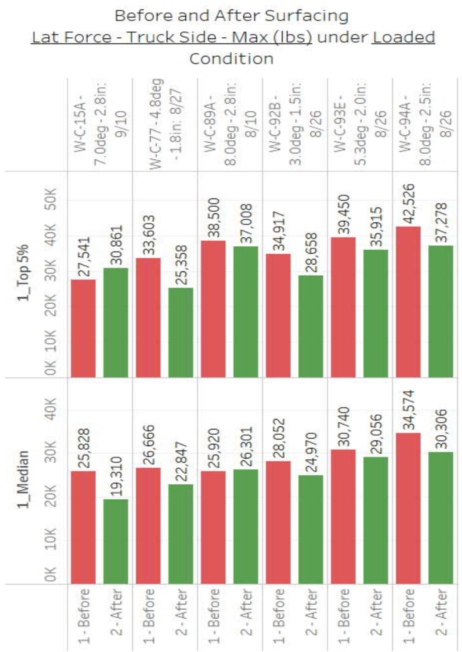
Case Study: Plate Cutting and Wide Gauge

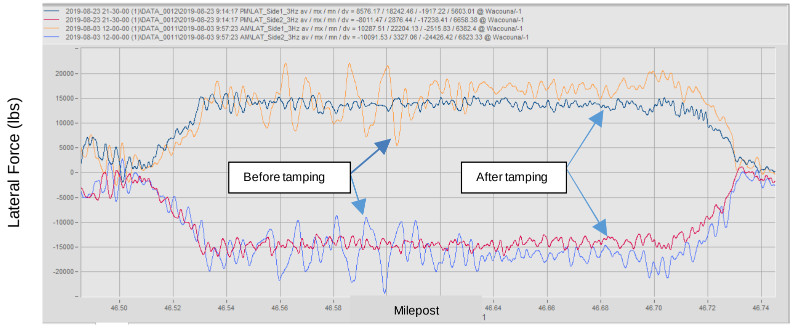
- IWS truck in leading position
- Each circle represents one measurement per each passing train
- About 50% of high-force curves identified by IWS (small circles) were NOT included in QNS&L maintenance plan
- QNS&L maintenance plan is based on traditional methods
- A parallel study showed a relationship between wide gauge and wheel shelling



Case Study: Assessment of Maintenance Effectiveness

- Before Tamping:
  - 15 kips P-P dynamic lateral force
  - 50% higher than quasi-static levels
- After Tamping:
  - Lateral forces ↓ to quasi-static levels
  - TSLF reduced for 5 out of 6 curves

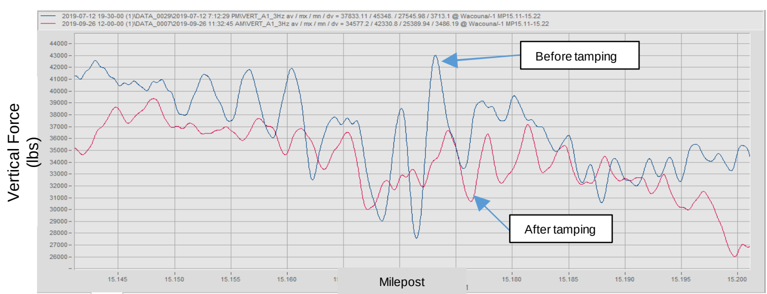




Lateral Forces Before and After Tamping

Case Study: Assessment of Maintenance Effectiveness

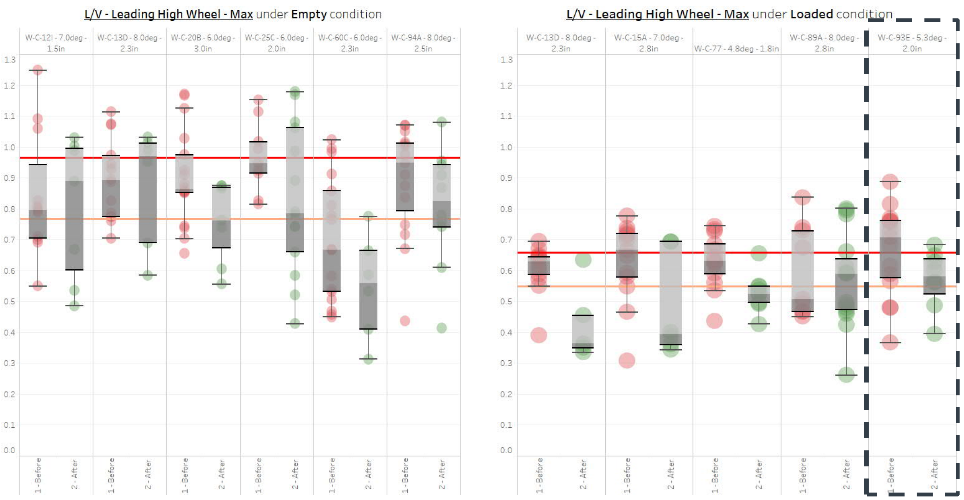
- Before Tamping:
  - 15 kips P-P dynamic vertical force
- After Tamping:
  - 6 kips P-P dynamic vertical force
  - Similar shape and wavelength → Tamping has not completely removed the track surface variation
  - Top 1% method: PPVF reduced for 2 out of 5 curves
  - Median PPVF values: reduced for 4 out of 5 curves



Vertical Forces Before and After Tamping

Case Study: Assessment of Maintenance Effectiveness

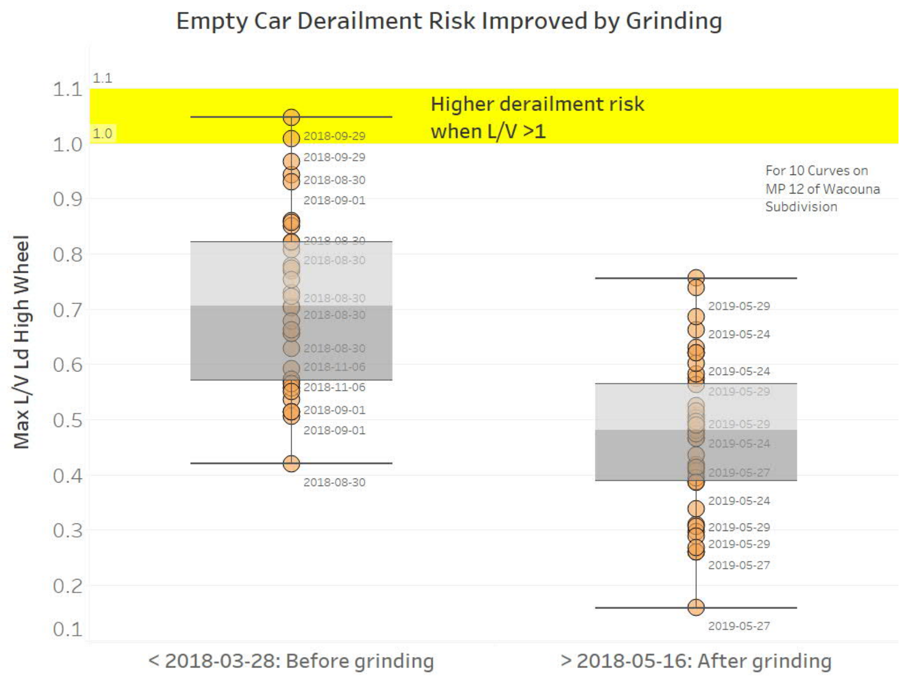
- L/V ratios under empty condition are higher than under loaded condition
- Maintenance work reduced wheel climbing risk
- Curve C93E was identified by IWS but not traditional methods



Lateral/Vertical (L/V) Ratios Before and After Tamping

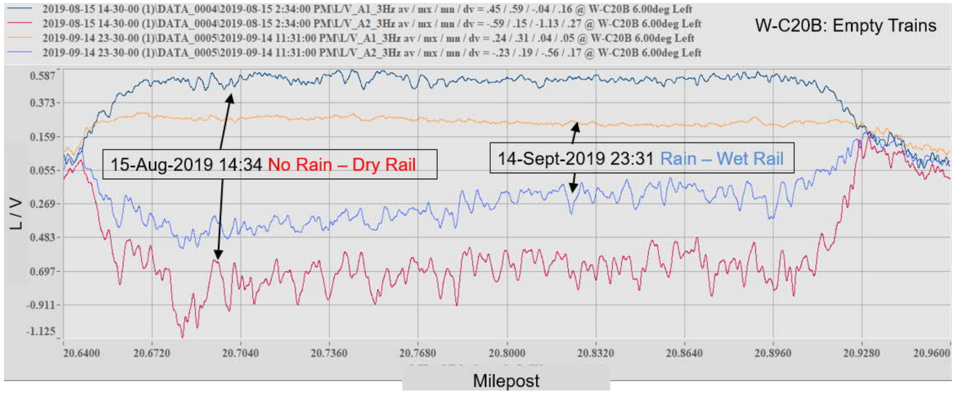
Case Study: Impact of Rail Grinding

- New Rail profile improved wheel/rail interaction and demonstrated the benefits of the Rail grinding program.
- Significant decrease of L/V Ratio, led to reduction of potential wheel climbing derailment.



Case Study: Effect of the Top-of-Rail Friction Modifier

- Rain acts like a Top-of-Rail friction modifier and reduces forces
- Top-of-Rail friction modification reduces wheel/rail lateral forces and is a potential mitigation for the wide gauge issue.
- QNS&L is considering the implementation of Top-of-Rail friction management program.



Conclusions

- New technologies are needed to monitor/inspect large rail networks;
- Successfully completed 1 year of in-service wheel/rail force monitoring using two Instrumented Wheelsets;
- Two force parameters, Truck Side Lateral Force and Peak to Peak Vertical Force were used to identify high-force locations on track;
- IWS identified high force locations before they cause track geometry defect;
- About 50% of high-force curves identified by IWS were NOT included in QNS&L maintenance plan.

Conclusions (Cont.)

- IWS technology can be used for continuous track monitoring applications, which will:
  - Perform real-time wheel/rail force measurements and near real-time analysis;
  - Decrease derailment risk;
  - Prioritize track inspection/maintenance;
  - Evaluate effectiveness of track maintenance activities; and
  - Support performance-based track maintenance planning → Enhancing track safety and performance.
- An ultimate track performance based maintenance system would include TG and IWS systems on the same truck, running frequently during in-service operations.

Thank YOU!

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