



# **Reducing Subway Noise and Vibrations**

**March-April 2019**

# | Subway Track System Overview

1. Sources of Noise and Vibrations (N&V)
  - a) Rail Infrastructure
  - b) Rolling Stock – **Dominant factor contributing to N&V since October 2018**
  
2. Rail Asset Inspection, Monitoring and Maintenance

## | Subway Vehicle Overview

1. Subway Train condition monitoring and impact of Emergency Breaking (EBs).
2. Wheel maintenance and repair.
3. Unusual and sudden increase of “wheel flats” in Q4 2018 and Q1 2019.
4. TTC action to address unusual increase of “wheel flats”.

# Subway Track System Overview

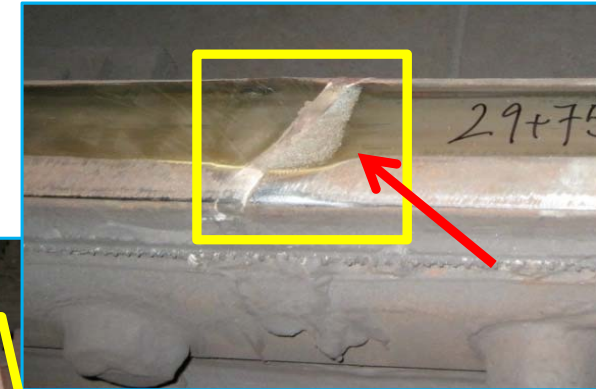
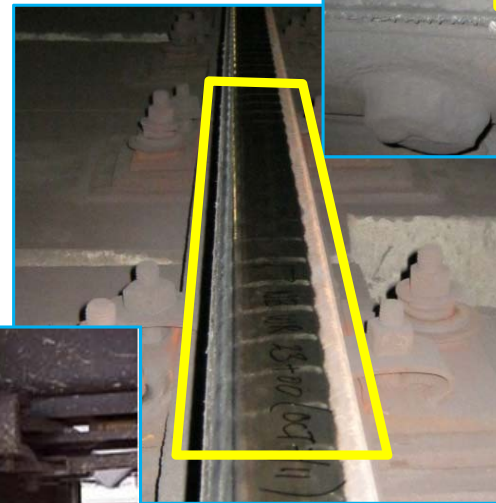
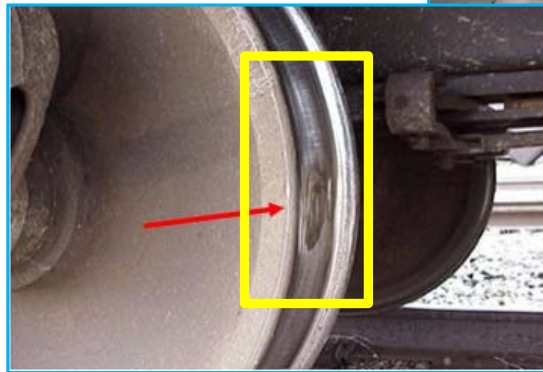
## Sources of Noise and Vibrations

### a) Rail Infrastructure

- Rail joints/welds
- Rail roughness (corrugation)
- Track curves (wheel/rail interface)

### b) Rolling stock

- Wheel uneven wear
- Wheel flat spots



# | Rail Infrastructure Inspection

## Inspection Activities

- Track Level Patrol and Riding Patrol
- Condition Based Monitoring (CBM)
- Rail Wear
- Rail Surface Corrugation Measurements (CAT and Vibration Train)
- Track Geometry

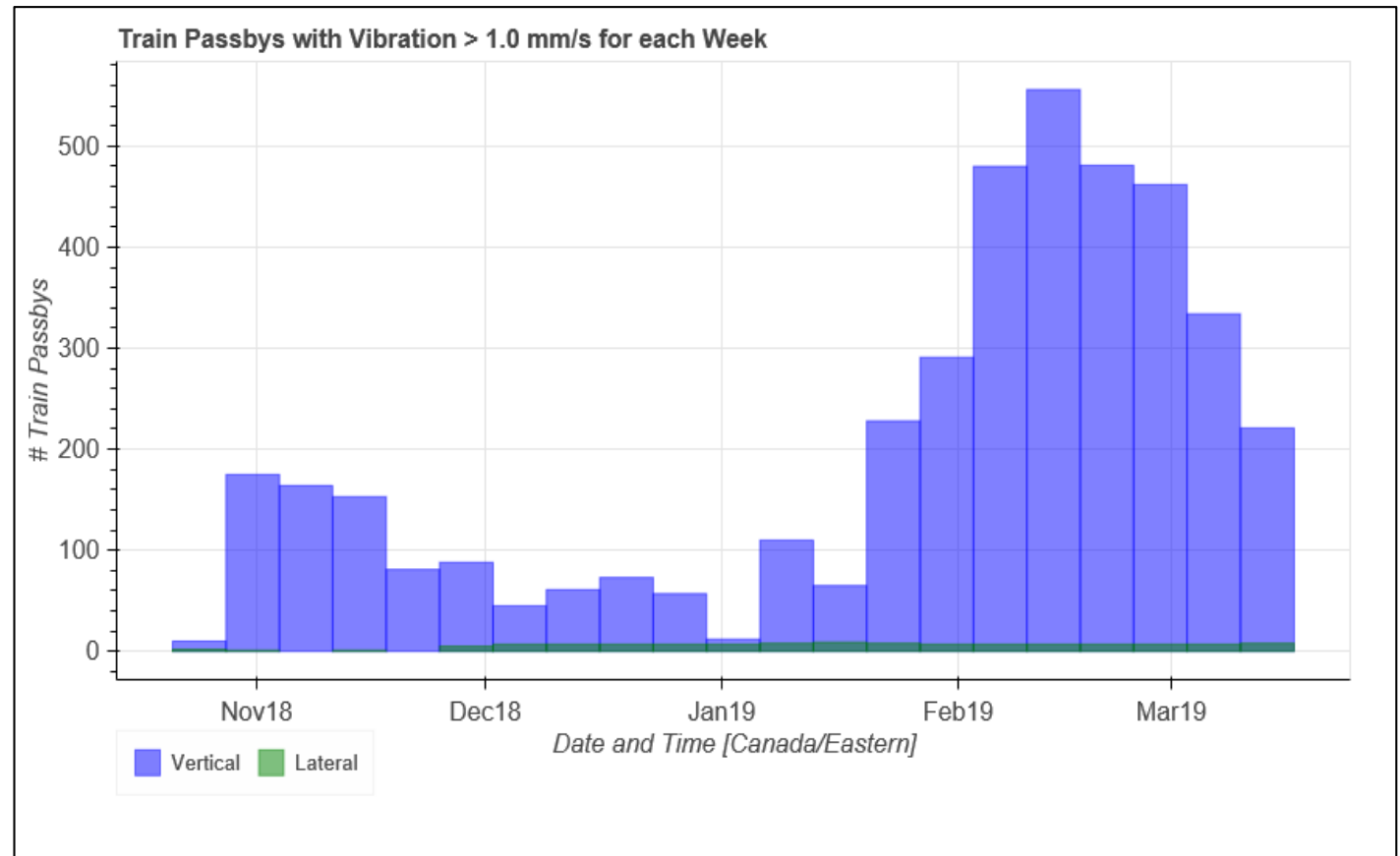
# | Rail Infrastructure Maintenance

## Maintenance Activities

- Rail Replacement
- Rail Grinding and Milling
- Uneven Joint Repair/Replacement
- Rail lubrication (reduce rail wear and squeal at curves)

## Vibration Monitoring Equipment

- Installed on Line 2 in 2019
- Measures the combined effect of wheel and localized rail conditions on the structure.



## Subway Noise – Vehicle Sources

- Line 2 – Sudden increases in flats have been the dominant factor contributing to N&V since October 2018.
- A subway “flat” is an indent on the running surface of the wheel.
- Flats range in size / varying degrees.
- A patterned thumping sound as wheels rotate along rail.

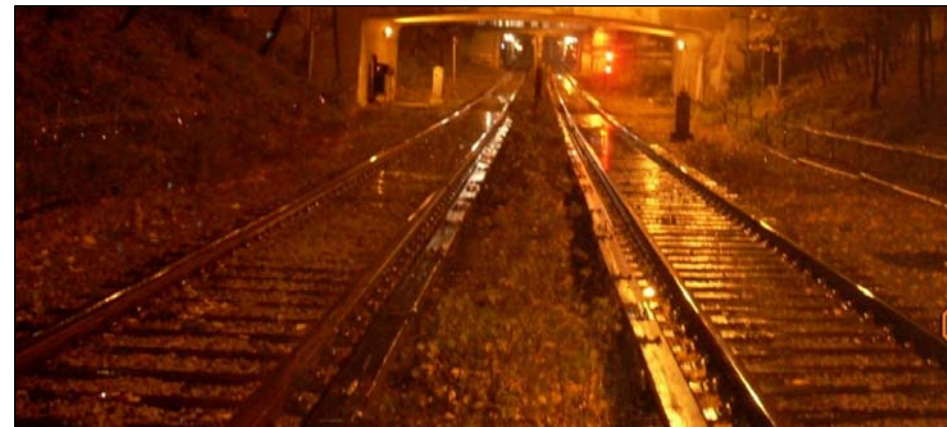
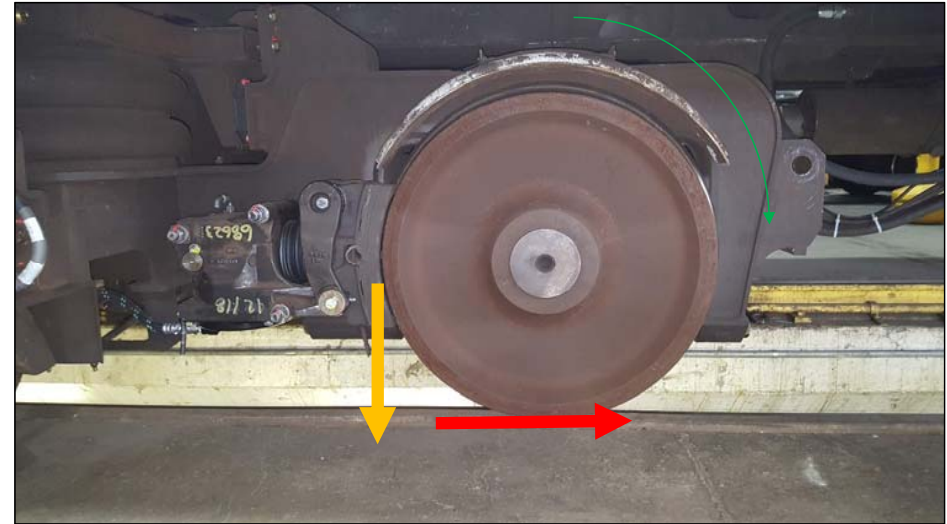




# Causes of Wheel Flats

## Low Traction

- Rail conditions combined with Emergency Braking (EB) can cause wheels to lose adhesion (slip), stop rotating and slide along the track.
- Wet rail, leaves, snow, and over-lubrication can cause areas of low traction.
- A “flat” is an indent on the running surface of the wheel.



## Causes of Wheel Flats continued

### Emergency Braking (EBs)

- Subway Operators may suddenly need to stop.
- The on-board “Speed Control” System will engage, as a safety override, and stop the train.



# | Rolling Stock Inspection and Maintenance

## Inspections:

- Thorough Visual Inspections - every 35 days
- Subway Operator reports
- Wheel Flat Detector - westbound at Warden Station - 24/7 real time

## Maintenance:

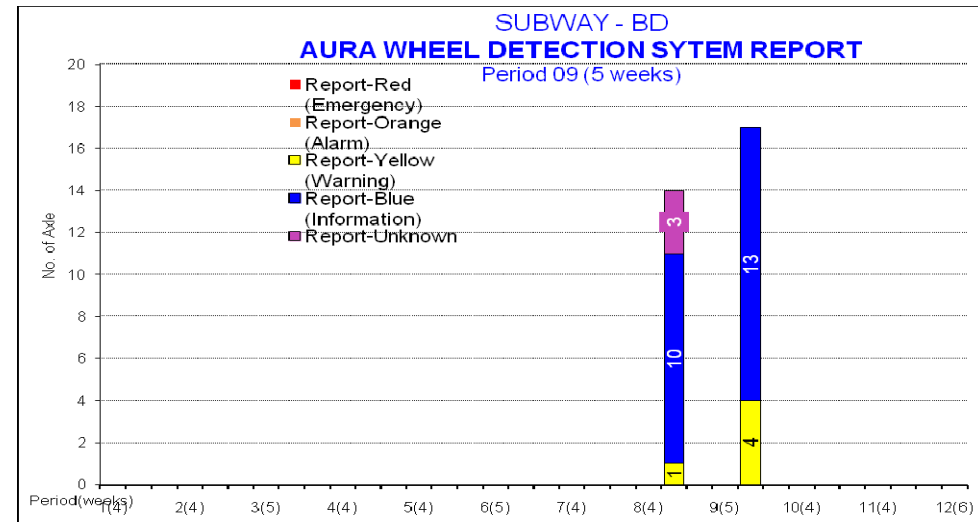
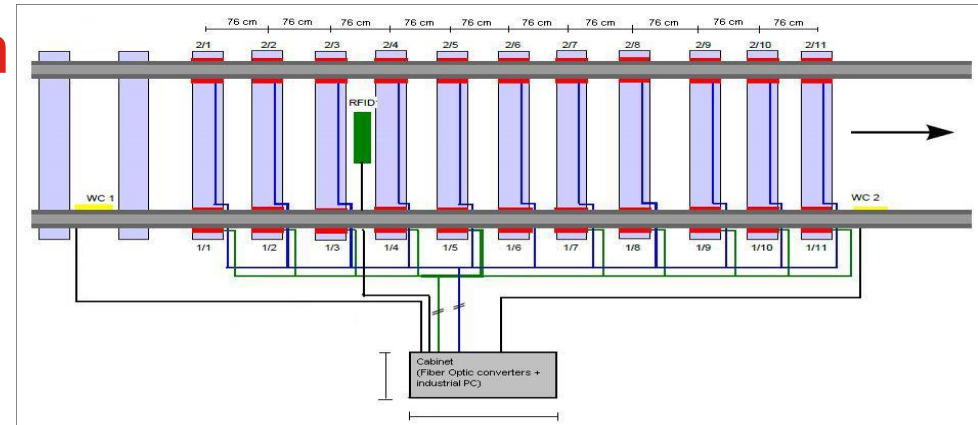
- Wheel truing/machining

## Wheel Flat Detection System - Line 2



# Wheel Flat Detection System

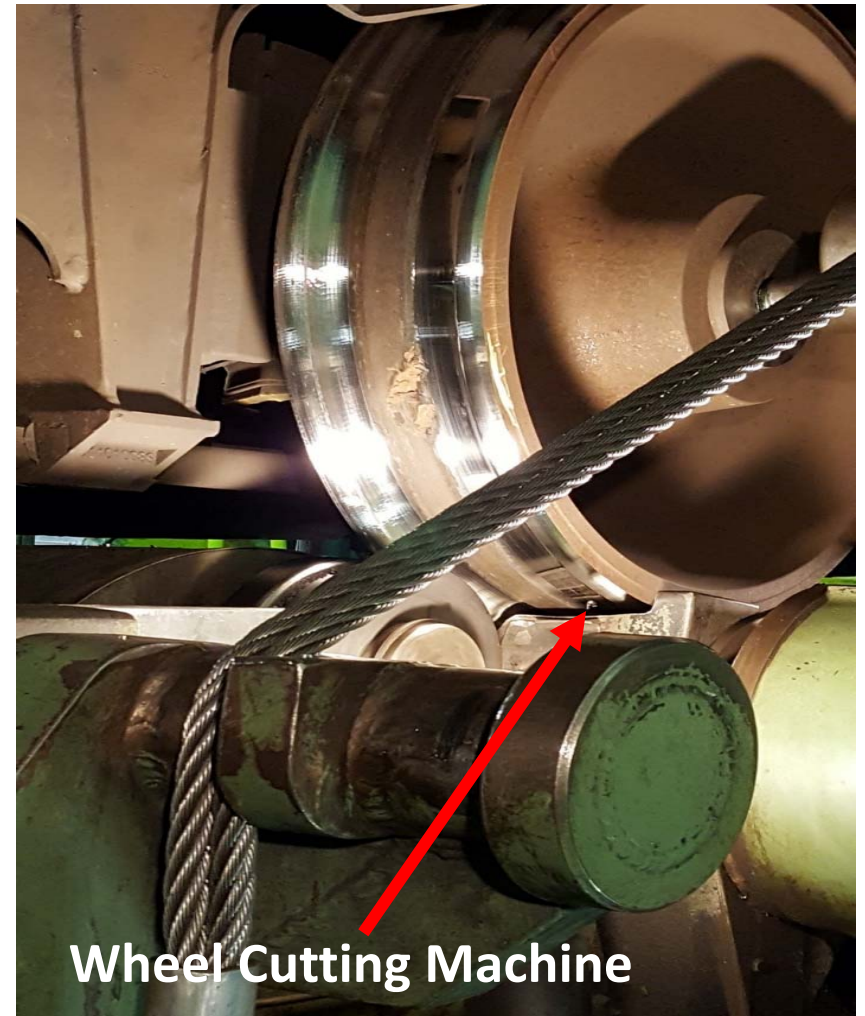
- Installed on Line 2 in 2012
- Installed on Line 1 in 2015
- Monitors wheel condition in real time (24/7)
- Detects wheel flats and can determine severity of wheel condition
- Measures and reports impact forces
- Identifies specific car axle and wheel to be repaired





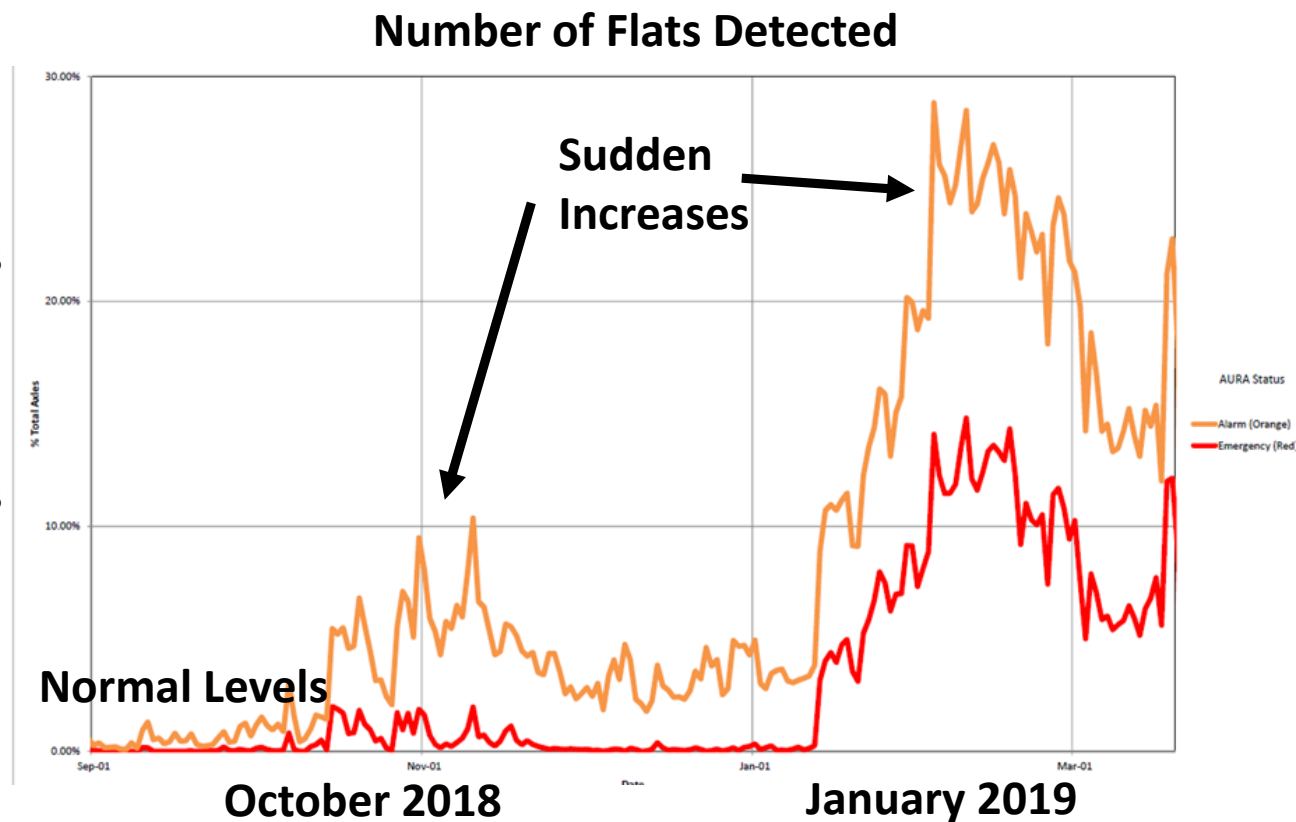
## Repairs for Wheel Flats

- Wheels are 'machined true' to remove flats and be re-profiled.
- A maximum of 6 axles (12 wheels) can be machined during an 8 hour shift.
- Wheel Turning Machines at both Greenwood and Wilson yards have been used at capacity to address current Line 2 wheel flat issue.



## Seasonal Flat Occurrences vs Winter 2018/19

- Wheel flats are a regular annually occurrence in the Fall.
- Abnormal sudden increases in “wheel flats” in October 2018 and January 2019.
- Unable to “machine” wheels faster than flats developed.
- Trains in service with wheel flats to meet service requirements.



## Status of Wheel Flats

- TTC equipment staff is making steady progress in reducing the number of flats as personnel continue to machine the wheels at full capacity.
- Some trains will operate with wheel flats during revenue service until numbers of flats are lower.
- TTC Engineers continue to engage the expertise of external experts as a thorough investigation into the root causes of wheel flats continues.



## Summary – Wheel Flats

- Engineering staff from Subway Infrastructure, Vehicles and Operations make-up part of the investigative group – root cause(s).
- Introduced speed restricted zones along various section of Line 2.
- Retention of National Research Council & Academic Engineering Expert for analysis -- assisting TTC to identify root cause(s).
- No single “smoking gun” identified by experts.

## Next Steps - Wheel Flats

- TTC will also be collaborating with other reputable N&V consultants.
- Continue regular inspections and monitoring of vehicles.
- Continue machining wheel flats at maximum capacity of carhouse.
- Efforts made to avoid placing vehicles with RED flats into service.
- **Definitive action plan and timeline available when the root causes have been identified.**